1959

Factors affecting the harvest of fish in the Des Moines River, Boone County, Iowa

James Carter Schmulbach
Iowa State University

FACTORS AFFECTING THE HARVEST OF FISH IN THE DES MOINES RIVER, BOONE COUNTY, IOWA

by

James Carter Schmulbach

A Dissertation Submitted to the
Graduate Faculty in Partial Fulfillment of
The Requirements for the Degree of
DOCTOR OF PHILOSOPHY

Major Subject: Fishery Biology

Approved:

Signature was redacted for privacy.

In Charge of Major Work

Signature was redacted for privacy.

Head of Major Department

Signature was redacted for privacy.

Dean of Graduate College

Iowa State University
Of Science and Technology
Ames, Iowa

1959

TABLE OF CONTENTS

FRONTISPIECE

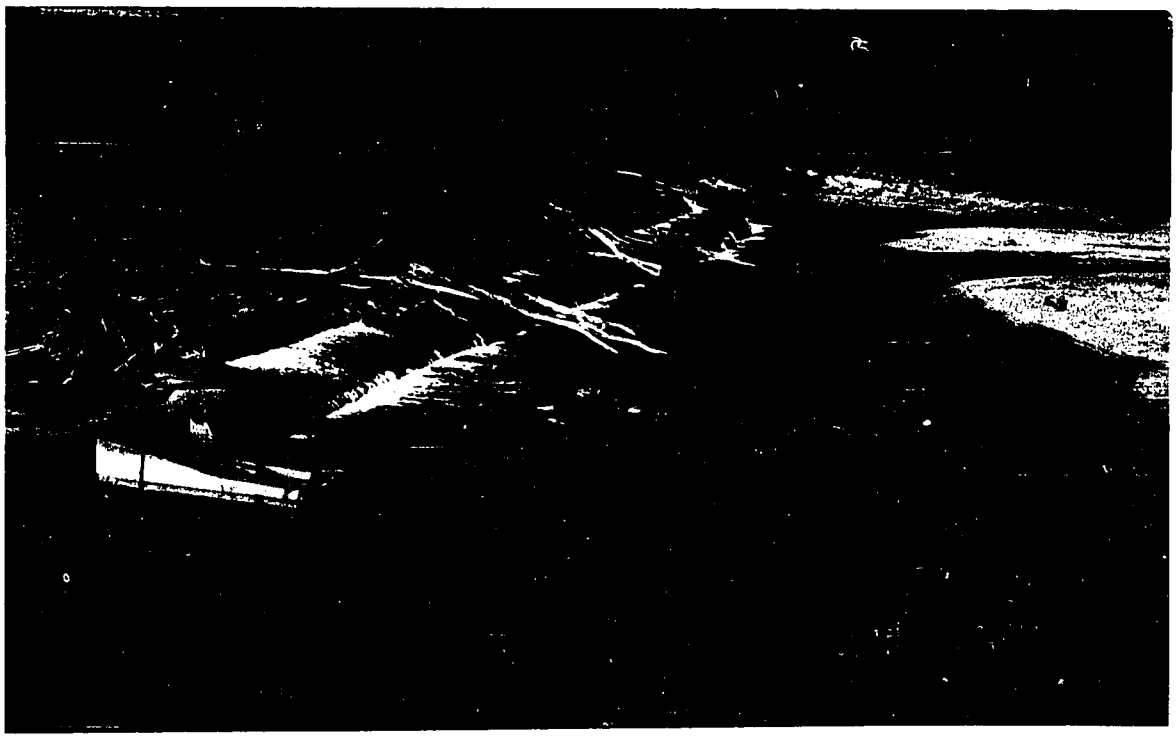
Fraser Dam

Boone Water Works Dam

FRONTISPIECE

Fraser Dam

Boone Water Works Dam



INTRODUCTION

Water is the most critical commodity which limits the existence of living organisms in many areas of the United States. The falling water table in many of our western states indicates that we are using ground water faster than it is being replenished. Since little can be done to replace the lost ground water, man has turned to the use and conservation of surface waters.

Streams, the primary form of surface water in many areas, must supply the bulk of the water necessary for human and livestock consumption; and municipal, industrial, agricultural, and recreational demands. Today our society is feeling the effects of a water shortage problem which is becoming more severe with each passing year. It has been estimated that by 1975 our country will have over 200 million inhabitants. In the future the rationing of water may be necessary. In a situation where the water is rationed, where will recreational demands stand on the priority list? More efficient use of water will be necessary in order to satisfy all the water needs of our society.

Recreational use of water is important to our society but more precise information on the use of water for boating, fishing, hunting, swimming, etc. is necessary. The recent increase in the interest of boating has increased the popularity of all water sports tremendously. Since most

streams have not been adequately surveyed to determine their recreational use and potential, the effects that use of water for other purposes would have on fish populations and fishing success are not known.

The Cooperative Fisheries Unit at Iowa State University undertook a survey of a segment of the Des Moines River to evaluate the use of the river by fishermen. Rivers such as the Des Moines are important to recreation primarily for fishing purposes. Some of the data collected may be of use in future management plans for the Des Moines River fishery. The purposes of the study were to:

1. Secure a satisfactory estimate of the angling pressure.
2. Determine the characteristics of the Des Moines River fishery.
3. Evaluate the factors which affect the harvest of fishes.

The central part of Iowa is deficient in natural lakes, reservoirs, and farm ponds and the streams of this section of the state supply the major source of water for recreation. The Des Moines River is the largest and most important river in this section of the state. The Iowa Conservation Commission has since 1953 conducted an annual creel census on the river (Harrison, 1957b). However, this census was designed to secure the mean rate of catch and to detect

trends in the fishery. Although no attempt was made to estimate the total amount of angling pressure, Harrison (1953) believed the sample of fishermen he interviewed was only a very small percentage of all fishermen utilizing the stream.

Previous fishery workers on the Des Moines River have concentrated primarily upon certain species or groups of fish. Bailey and Harrison (1948) did a comprehensive study on the food habits of the channel catfish. Starrett (1950a, 1950b, 1951) studied the ecological and food relationships of the minnows and also studied the distribution of the fishes of Boone County with special reference to the minnows and darters. Muncy (1957) checked the distribution and movements of the channel and flathead catfish through an intensive tagging and netting operation. Aspects of the life history of the river carpsucker and the carp were studied by Buchholz (1957) and Rehder (1959) respectively. No attempt had been made to estimate the total harvest of fish nor the amount of fishing provided until the present study was initiated.

The Des Moines River is the largest inland river flowing entirely through the state of Iowa. It originates in a glacial moraine in southwestern Minnesota and flows in a southeasterly direction across Iowa into the Mississippi River, a distance of 535 miles. Its total drainage area is approximately 14,500 square miles, of which 93 percent is

in agricultural usage (U.S. 71st Congress, 1931). The average annual rainfall for the watershed is approximately 30 inches. The heaviest precipitation usually occurs in May or June.

Approximately mid-way in its course, the Des Moines River passes through Boone County. In Boone County the stream gradient of 1.5 feet per mile insures a reasonably rapid flow of water. The water is quite turbid during most seasons and silt pollution was the only type of pollution observed during this investigation.

The bottom of the river consists primarily of sand, gravel, sand-silt, rubble and boulders. The depth of the river in summer probably averages less than 3 feet but there are deep holes downstream from sand bars, boulders, and brushpiles. Quickly rising and falling water levels are common in the spring and early summer. During the winter, the river in Boone County is covered by ice except for small areas just below the spillway of dams. For a more complete description of the Des Moines River study area see Starrett (1950a).

Description of the Research Area

The section of the river in Boone County which lies between the lowhead dam at Fraser and the Boone Water Works Dam was the area chosen for intensive study (Figures 1 and

2). The study area includes approximately 6.5 miles of stream, but in previous studies this distance has been rounded off and reported as 7 miles. The average width of the Des Moines River in Boone County is reported as 250 feet (U.S. 71st Congress, 1931). The total acreage of water in the study area was, therefore, 179 acres. The encircled numbers in Figure 2 are stations which were assigned arbitrarily to certain areas of the river which could be identified by some prominent landmark. These stations were used in recording the distribution of fishing pressure and the extent of movement of tagged fish. The two lowhead dams, stations 1 and 20, which approximately mark the upper and lower boundaries of the study area are typical of lowhead dams which may be found along the Des Moines River (see Frontispiece). At least 28 lowhead dams have been constructed on the Des Moines River. Many of these dams have since been destroyed completely but others, or their remnants, still serve as concentration points for anglers. The dams at Estherville, Rutland, Humboldt, Fraser, Boone, Des Moines (Center Street and also Scott Street), and Ottumwa are well-known fishing locations.

Figure 1. Des Moines River in Boone County, Iowa.

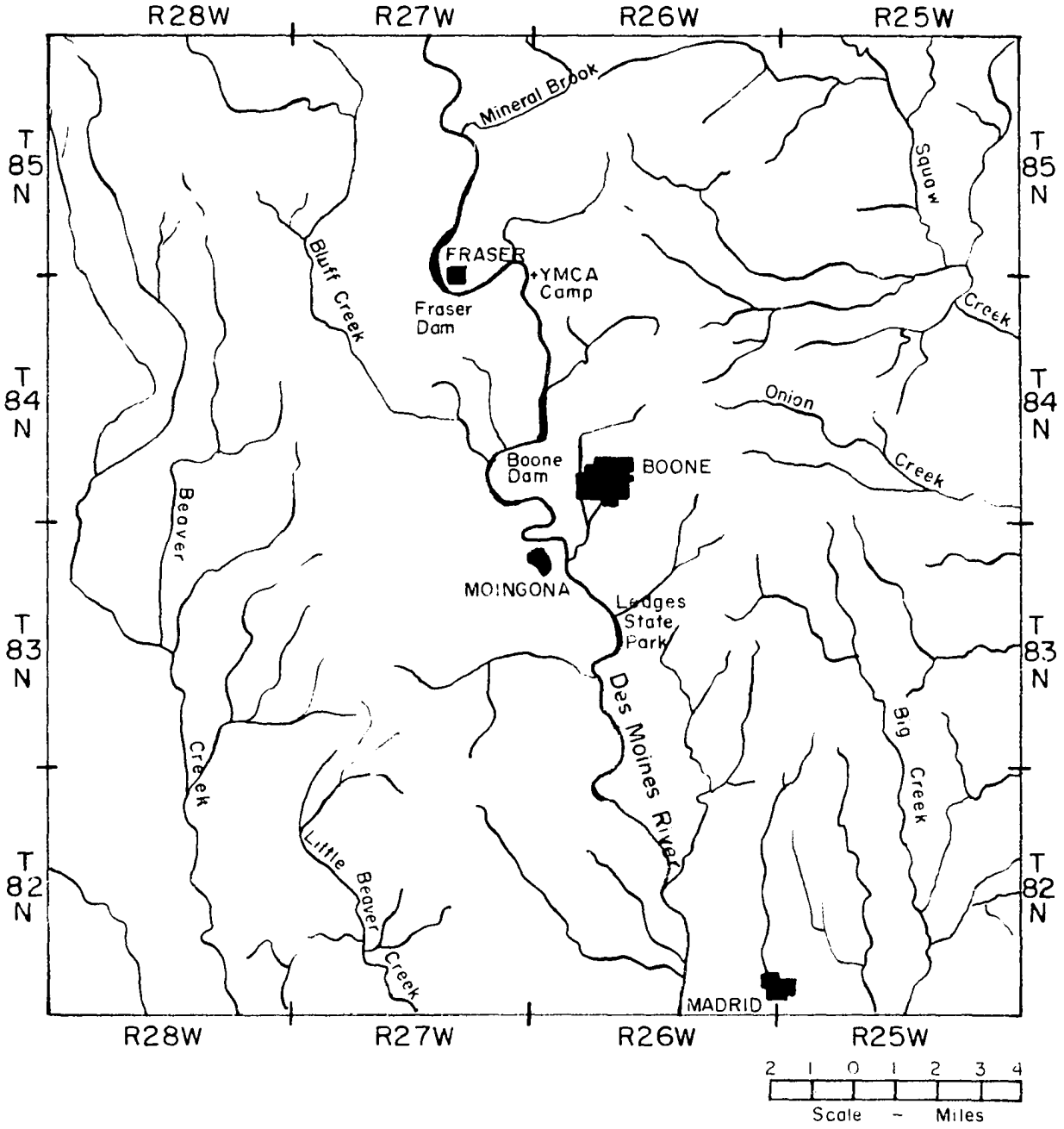
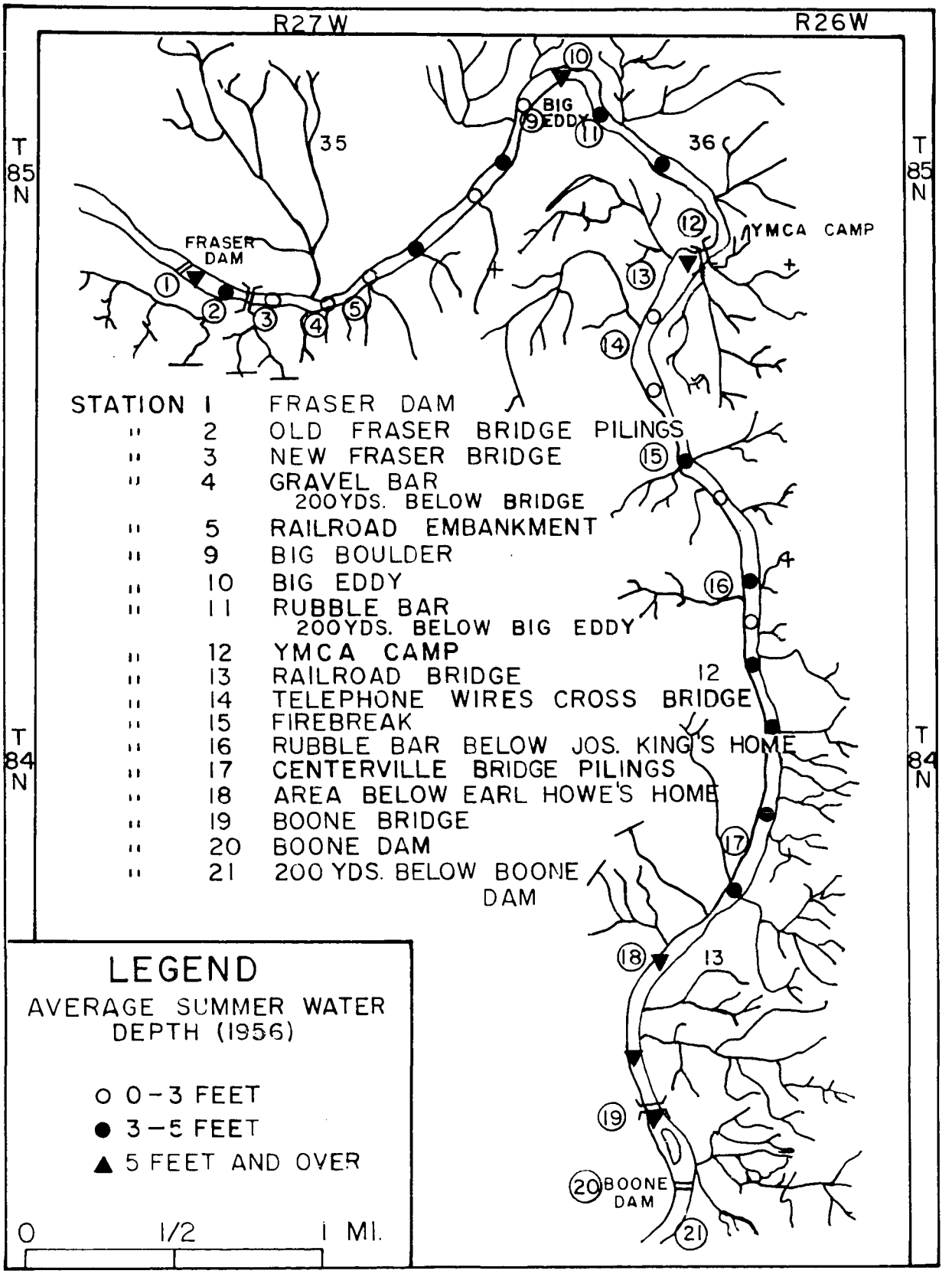

R28W
R27W
R26W
R25W
T 85 N
T 84 N
T 83 N
T 82 N
Mineral Brook
Squaw Creek
Bluff Creek
FRASER
+YMCA Camp
Fraser Dam
Onion Creek
Boone Dam
BOONE
Beaver Creek
MOINGONA
Ledges State Park
Des Moines River
Big Creek
Little Beaver Creek
MADRID
2 1 0 1 2 3 4
Scale - Miles

Figure 2. Study area of the Des Moines River from Fraser Dam to the Boone Water Works Dam, Boone County, Iowa.


R27W
R26W
T 85 N
T 84 N
35
36
BIG EDDY
FRASER DAM
YMCA CAMP
12
13
STATION 1 FRASER DAM
" 2 OLD FRASER BRIDGE PILINGS
" 3 NEW FRASER BRIDGE
" 4 GRAVEL BAR 200YDS. BELOW BRIDGE
" 5 RAILROAD EMBANKMENT
" 9 BIG BOULDER
" 10 BIG EDDY
" 11 RUBBLE BAR 200YDS. BELOW BIG EDDY
" 12 YMCA CAMP
" 13 RAILROAD BRIDGE
" 14 TELEPHONE WIRES CROSS BRIDGE
" 15 FIREBREAK
" 16 RUBBLE BAR BELOW JOS. KING'S HOME
" 17 CENTERVILLE BRIDGE PILINGS
" 18 AREA BELOW EARL HOWE'S HOME
" 19 BOONE BRIDGE
" 20 BOONE DAM
" 21 200 YDS. BELOW BOONE DAM
LEGEND
AVERAGE SUMMER WATER DEPTH (1956)
o 0-3 FEET
● 3-5 FEET
▲ 5 FEET AND OVER
0 1/2 1 MI.

METHODS AND PROCEDURES

Proper evaluation of the nature and quality of a sports fishery and the harvest of fish from such a fishery are obtained from well-planned survey techniques. Such a survey is known as a creel census. A good creel census is a tool used by management and research in procuring such data as: (1) total fishing effort in fisherman-hours; (2) catch per unit-effort; (3) species composition of the catch; (4) age classes and size groups represented in the catch; (5) total annual yield in numbers and weight; (6) methods, tackle, and baits used; (7) age, sex, and residence of anglers; and (8) expense incurred in pursuit of the sport.

The first creel census was devised in Michigan during the 1920's (Fry, [ca. 1949]; Fukano, 1948; Solman, 1951). Since that first creel census a wealth of papers on creel censuses have been published. Many different techniques have been used. Perhaps the most accurate have been those surveys which effected complete enumeration of all anglers. Fry (1949) used a complete census in obtaining valuable statistics in a lake-trout fishery. All fishermen had to pass check points in order to enter or leave the fishing area. Shetter (1950) and Lagler and DeRoth (1953) obtained complete creel data from small streams and ponds in Michigan. Other investigators have, with much effort, conducted creel censuses which were almost complete (Eschmeyer, 1939;

Thompson and Hutson, 1951; King and Currier, [ca. 1951]; Rupp, 1955). Compulsory censuses which required anglers who fished in certain "test" waters to report their catch were used successfully by Lord (1935, 1937, 1941, 1946); Cooper (1952, 1953); Heacox (1946); Holloway (1948); Starrett and McNeil (1952); and Thorpe (1938).

Soliciting voluntary creel census information through postal mail questionnaires, fisherman diaries, or cards which may be completed and dropped in a collection box or pinned to a tree have been attempted. In most cases voluntary creel census data are of questionnable value (Clark et al., 1948; Solmon, 1951; Younger and Hamer, 1954). However, Calhoun (1950) obtained what he considered valuable information using a statewide mail questionnaire survey. Allen (1951), Bishop (1955), Cleary (1953, 1956), and Phenicie (1955) used fisherman diaries or log books in obtaining usable creel census data. A few other workers have reported obtaining usable data from voluntary creel census cards (Cope, 1957; Moore et al., 1952; and Murphy, 1955). Wandell (1946) obtained satisfactory returns from hunters on a study area by issuing them cards to which a pencil and a thumb tack were attached. After completing their hunting trip the cards were attached to the nearest tree and picked up at a later date by the investigator. This same technique was modified for a creel census and used with excellent

success by Mackenthun and Herman (1949).

The most common method of securing angling statistics has been to personally contact anglers either while they were actively engaged in angling or shortly after their fishing trip had been completed. In most cases due to the large size of a body of water or for some other reason it has been impossible to contact all anglers. Therefore, techniques which randomly sample a segment of the fishermen must be used. Well-planned and -executed sample surveys can be expected to provide estimates within acceptable limits of error at less than 100 percent coverage. Attempts to determine empirically which of several sampling schemes was most efficient were made by Best and Boles (1956), DiCostanzo (1956), and Randle (1938). The work of DiCostanzo on Clear Lake, Iowa, served as a guide in formulating the survey technique used in the present study. A stratified random sampling technique known as the Latin-square design was used with various modifications.

Definitions

As in other fields, special notation peculiar to creel-census surveys has appeared. Various workers have assigned different meanings to much of the terminology. Therefore, the terms as used in this study are defined below.

Sample creel survey

A sample creel survey is a creel census which involves sampling of fishermen to obtain catch data. Not all of the fishermen are counted or contacted but only a representative sample is included in the survey.

Incompleted- and completed-fishing contacts

Incompleted-fishing contacts are those contacts which are secured while the angler is in the act of fishing. Completed-fishing contacts are those obtained after the angler's trip is completed.

Unit of effort

The unit of effort adopted for the purposes of the present study was the fisherman-hour (one person fishing for one hour). On one occasion a pole-hour was used as a measure of fishing pressure. In Iowa, a fisherman may legally use two poles. A pole-hour is defined as one pole being fished for one hour.

Catch per unit of effort

A common measure of fishing success or fishing quality is the ratio of the catch (numbers or weight of fish) to effort. In the present study the number of fish caught (which were kept) per hour of fishing was used as the standard. This ratio was estimated by dividing the total recorded catch of fish in numbers by the total number of hours

expended and will be referred to as the catch per fisherman-hour or man-hour or angler-hour.

Fishing party

A fishing party was considered as one or more anglers who were fishing together and who usually came to the river in the same vehicle. Only one member of each fishing party was interviewed.

Angler Counts

One of the primary objectives of the creel census was the estimation of the total fishing pressure. Within each 2-hour sampling period counts of the fishermen were made according to seasonal schedules based upon Latin-square designs. Rigid adherence to the prearranged dates and hours of each census was exercised. Fishermen were recorded separately according to their sex and method of fishing (i.e., boat fishermen, shore fishermen or waders). Whenever the river was navigable, a small flat-bottomed, 12-foot boat equipped with a 5-horsepower motor was used to traverse the river and make the angler counts. When the river was not navigable for the small boat, an automobile was used to cover the area being censused. Much of the river was readily accessible to individuals with vehicles and it was felt that accurate counts were made when an automobile was used to cover the route. In many instances a boat was used to

cover the lower half of the study area while the more shallow upper portion of the area had to be covered with an automobile (Figure 2). A pair of 7 x 50 binoculars was helpful in locating fishermen along the banks.

Angler Contacts

Angling statistics were secured through personal contact with anglers. Whenever time permitted, personal interviews were conducted during the 2-hour sampling periods in which the angler counts were made. When time did not permit angler contacts within the 2-hour periods, the interviews were made immediately before or after the angler counts. Since there was a large number of access points and time and manpower were limited, it was impossible to secure information only from anglers who had completed their fishing trips. Consequently, most anglers were interviewed while they were in the act of fishing. On heavily fished days more contacts were made than on lightly fished days. Conversely, a smaller percentage of the anglers were usually contacted on heavily fished days than on lightly fished days. On lightly fished days all or almost all of the fishermen were contacted. Whenever fishing pressure was exceptionally heavy, an attempt was made to census a fixed percentage of the anglers at any given concentration point. Since shore anglers were more easily censused than waders or

boat fishermen, a special effort was made to interview the waders and boat fishermen. A considerable amount of wading on the part of the investigator was necessary to reach many of the fishermen.

Not all anglers were asked to display their catches when interviewed. At the onset of the study most of the catches were examined by the census taker. As the researcher became more familiar with the local anglers, it became unnecessary to view the reported catches. However, many anglers voluntarily showed their catches when approached by the census taker. Most walleyes and smallmouth bass were individually weighed and measured and some channel and flathead catfish were similarly recorded. In most instances, however, total lengths and weights were estimated.

Information from all contacted fishing parties included the following: (1) length of time fished; (2) length of time the party expected to fish; (3) number of each species comprising the catch; (4) sex of the person fishing; (5) method of fishing (i.e., boat, shore, or wading); (6) location on the river; (7) number of anglers in the party; (8) number of lines used; (9) type of tackle; (10) bait; (11) place of residence; and (12) transportation used to reach the river. All elderly appearing males were asked whether they were retired. In many instances where the angler was personally known to the census taker, his name was recorded

on the census card.

The species of fish caught by anglers in the Des Moines River during the course of this investigation included:

Catostomidae

Carpiodes carpio (Rafinesque) - river carpsucker

Carpiodes cyprinus (LeSueur) - quillback carpsucker

Moxostoma erythrurum (Rafinesque) - golden redhorse

Moxostoma anisurum (Rafinesque) - silver redhorse

Moxostoma aureolum (LeSueur) - northern redhorse

Catostomus commersoni (Lacepede) - white sucker

Hypentelium nigricans (LeSueur) - hog sucker

Ictiobus cyprinellus (Valenciennes) - bigmouth buffalo

Cyprinidae

Cyprinus carpio Linnaeus - carp

Ictaluridae

Ictalurus melas (Rafinesque) - black bullhead

Ictalurus punctatus (Rafinesque) - channel catfish

Noturus flavus Rafinesque - stonecat

Pylodictis olivaris (Rafinesque) - flathead catfish

Centrarchidae

Ambloplites rupestris (Rafinesque) - rock bass

Lepomis cyanellus Rafinesque - green sunfish

Micropterus dolomieui Lacepede - smallmouth bass

Pomoxis annularis Rafinesque - white crappie

Pomoxis nigromaculatus (LeSueur) - black crappie

Percidae

Stizostedion vitream (Mitchill) - walleye

In the tables all members of the family Catostomidae were classed as "suckers" except for the bigmouth buffalo which because of its larger size was listed under the heading of "others".

The general weather conditions, water temperature, air temperature, turbidity readings, and water-level readings were recorded during the course of this study in an attempt to evaluate whether these factors were correlated with fishing success. Surface water temperatures were recorded with a hand thermometer at the same time the angler counts were made. Turbidity readings were taken with a secchi disc and all measurements were recorded in inches. The average air temperature was considered to be the mid-point between the daily high and low temperatures recorded by the U.S. Weather Bureau near Boone and published monthly in a report of the Iowa climatological data. Water levels were taken daily at the Boone Water Works Dam by the Water Resources Division of the U.S. Geological Survey. These daily records are kept on file at the state office in Iowa City. All measurements were recorded as height of the water in feet flowing over the crest of the dam.

Fish Tagging

In addition to the creel census a fish-tagging program was continued on the river. During the years 1955 and 1956 a total of 3,077 channel catfish and 168 flathead catfish were tagged and released by members of Iowa Cooperative Fisheries Unit (Muncy, 1957). During 1957 and 1958 a total of 259 channel catfish, 31 flathead catfish, 48 walleyes, and 18 smallmouth bass were tagged and released. This tagging study was continued to determine the minimum annual rate of harvest by anglers and to check the movements of the tagged fish. Since a creel census was being conducted concurrently with a tagging operation, it was felt that a large percentage of the tags would be reported by the anglers. All species of fish were tagged with numbered monel metal strap tags, sizes 1 and 3. Tags were placed over the premaxillary and maxillary bones of the walleyes and smallmouth bass while channel and flathead catfish were tagged on the opercular bone.

EVALUATION OF SURVEY METHOD USED

Reliability of Data from Incompleted-Fishing Contacts

Where the access points of a body of water are limited or the number of census takers is great, surveys relying upon completed-fishing contacts are usually used (Eschmeyer, 1936; Kathrein, 1953; Rupp, 1955). In studies of most large lakes and rivers it is usually impractical to contact only fishermen who have completed their fishing trips because of the large number of access points. Consequently, in the present study the data collected were secured primarily from incompleted-fishing contacts.

It is possible that surveys relying upon incompleted-fishing contacts may be biased (Moyle and Franklin, 1953; DiCostanzo, 1956). Schultz (1958) concluded that hunting success based on incompleted- and completed-bag data were not comparable. There are two requirements which must be satisfied if data from incompleted-fishing trips are to be unbiased: (1) the rate of catch must average the same throughout all hours of the fishing trip; and (2) the rate of catch must be the same for anglers who fish a short period of time as for those anglers who fish a long period of time.

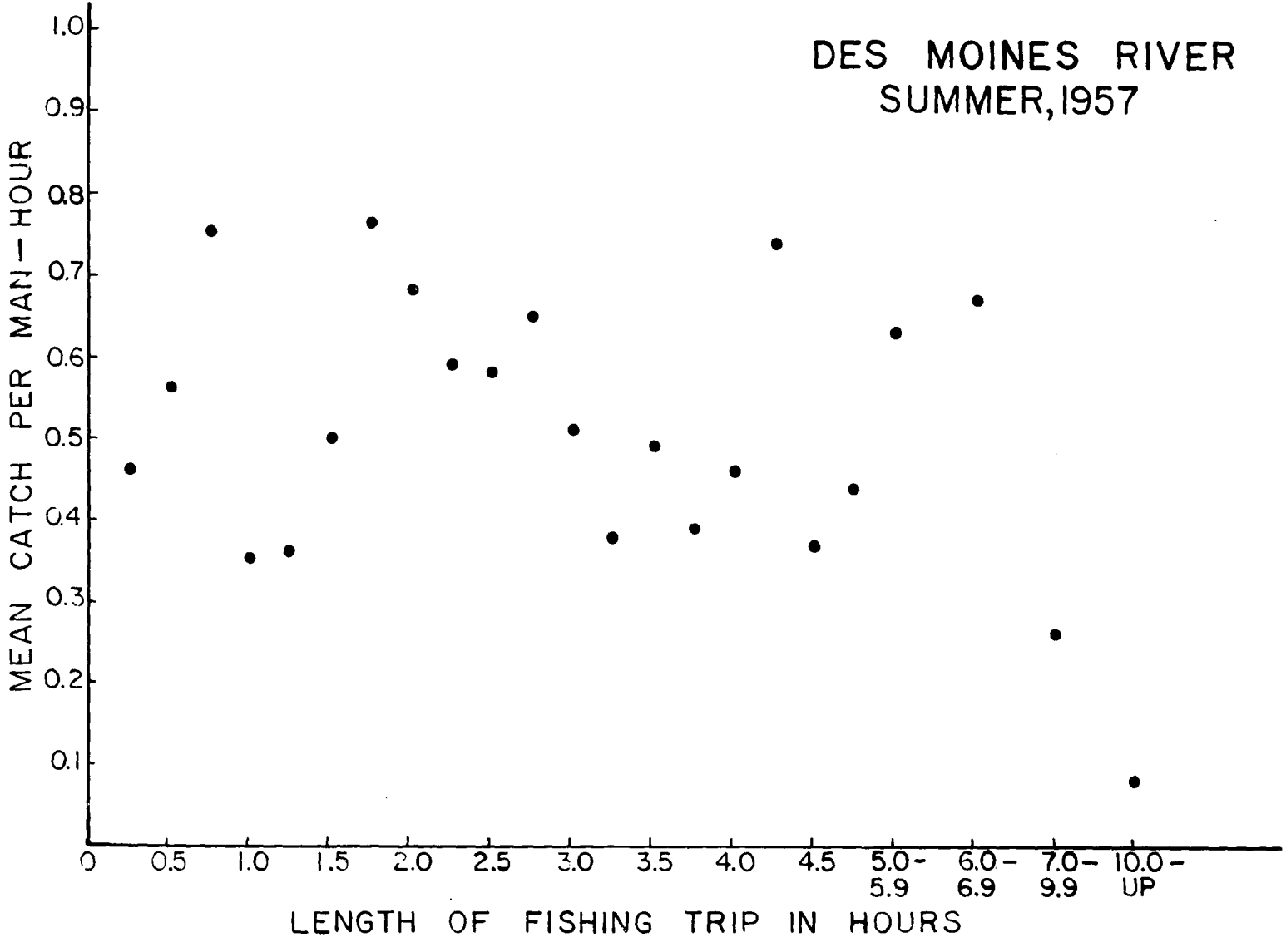
To ascertain a possible relationship between catch per man-hour and length of the fishing trip, a scatter diagram

of the 1957 summer season was prepared (Figure 3). All fishing trips were computed to the nearest one-quarter hour and mean rates of catch were used. The plotting of mean rates of catch for each length of fishing trip does obscure much of the variability about the mean rate of catch, but this was done to eliminate the necessity of graphing a large number of points. Fishing trips longer than 5 hours were combined into one-hour groups or larger groups. Fishermen specifically seeking flathead catfish were not included in the results since many anglers who fish for flathead catfish angle all night and are actually a separate group of fishermen.

From Figure 3 it is evident that there was no tendency for the rate of catch to fall or rise with the length of the fishing trip. However, there is an indication that fishing trips over 7 hours long may experience a lower rate of catch. There are several possible explanations for this observation. First of all, the attentiveness of the angler may become more relaxed as the hours pass and fishing success remains poor. Secondly, many anglers may have stopped fishing completely for an hour or more in the middle of their fishing trip and failed to inform the census taker of their actions.

All fishermen were asked how long they intended to fish. This is a subjective question and liable to consider-

Figure 3. Relationship between mean rate of catch and length of time fished, Des Moines River, summer 1957.


DES MOINES RIVER
SUMMER, 1957
MEAN CATCH PER MAN—HOUR
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0-5.9
6.0-6.9
7.0-9.9
10.0-UP
LENGTH OF FISHING TRIP IN HOURS

able error but if the mean catch per man-hour is plotted against the percentage of the fishing trip completed at the time of the interview, no linear relationship between the rate of catch and the completeness of the fishing trip could be noticed (Figure 4). There was an indication that after an initial high rate of catch the fishing got poorer until at least one-half of the trip was completed. Perhaps this suggests a curvilinear relationship. After 50 percent or more of the trip was completed, the fishermen may have turned their efforts towards catching more available species or sizes of fish and, consequently, the rate of catch improved. Another possibility is that fishermen who have been fishing for a few hours may indicate that they will fish longer if their catch has not been good up to that time than if their catch were good. It was concluded from the scatter diagrams that the use of incompleted-fishing contacts did not bias catch per man-hour statistics.

Additional support for the reliability of incompleted-fishing contacts in estimating the rate of catch is furnished by comparing the catch per hour of completed and incompleted fishing trips (Table 1). Although the observed catch per effort ratios for completed fishing trips were higher in all seasons but one, a chi-square test as described by Snedecor (1956, p. 226) indicated that the observed differences were not statistically significant at

Figure 4. Relationship between mean rate of catch and the percentage of the fishing trip believed to be completed at time of interview.

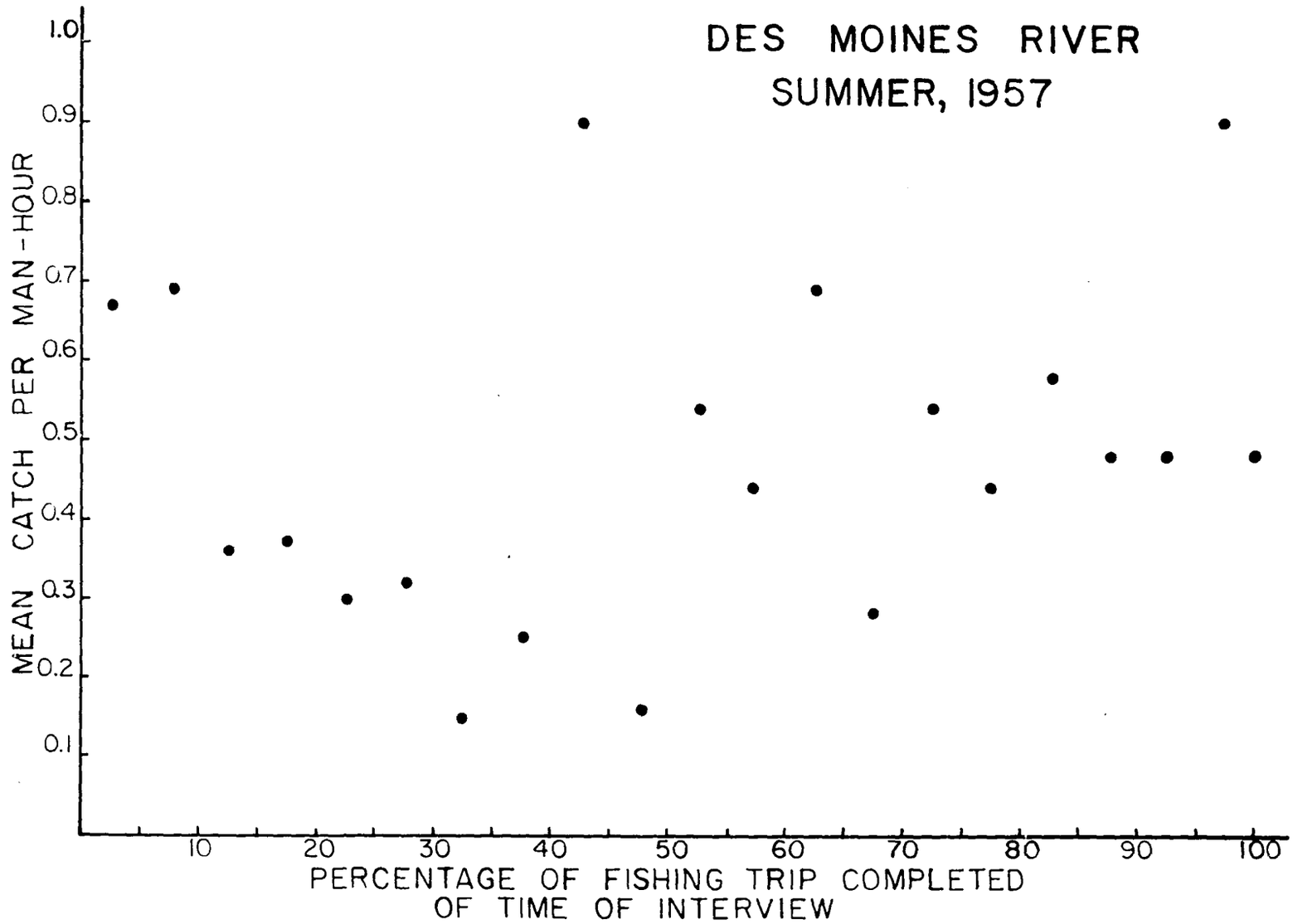
Table 1. Mean catch per man-hour for completed and incompleted fishing trips on a 6.5-mile section of the Des Moines River, July 7 to August 24, 1957[a].

Season	Boat	Shore	Waders	Total
Summer-1957				
Completed	0.42(17)	0.48(74)	0.61(14)	0.49
Incompleted	0.63(69)	0.46(854)	0.28(135)	0.44
Total	0.56	0.46	0.31	0.45
Fall-1957				
Completed	-	0.34(24)	0.23(5)	0.30
Incompleted	0.47(12)	0.29(326)	0.14(45)	0.27
Total	0.47	0.29	0.15	0.28
Spring-1958				
Completed	0.53(2)	0.58(31)	0.50(1)	0.58
Incompleted	0.30(25)	0.26(554)	0.58(20)	0.28
Total	0.34	0.29	0.57	0.30
Summer-1958				
Completed	0.65(13)	0.55(56)	0.0(1)	0.58
Incompleted	0.35(55)	0.37(608)	0.23(49)	0.36
Total	0.50	0.39	0.23	0.40
Fall-1958				
Completed	0.19(6)	0.14(10)	0.28(3)	0.17
Incompleted	0.50(5)	0.20(211)	0.20(31)	0.21
Total	0.35	0.20	0.20	0.21
Grand Total	0.49	0.37	0.28	0.37

[a]Numbers in parentheses indicate the number of anglers interviewed.

the 95 percent probability level ($x^2 = 6.864$; d.f. = 4).

It appears, insofar as the Des Moines River fishery was concerned during the period covered by the study, that there were no inherent errors in the use of incompleted-fishing contacts to estimate catch per man-hour. The use of


DES MOINES RIVER
SUMMER, 1957
MEAN CATCH PER MAN-HOUR
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
10
20
30
40
50
60
70
80
90
100
PERCENTAGE OF FISHING TRIP COMPLETED
OF TIME OF INTERVIEW

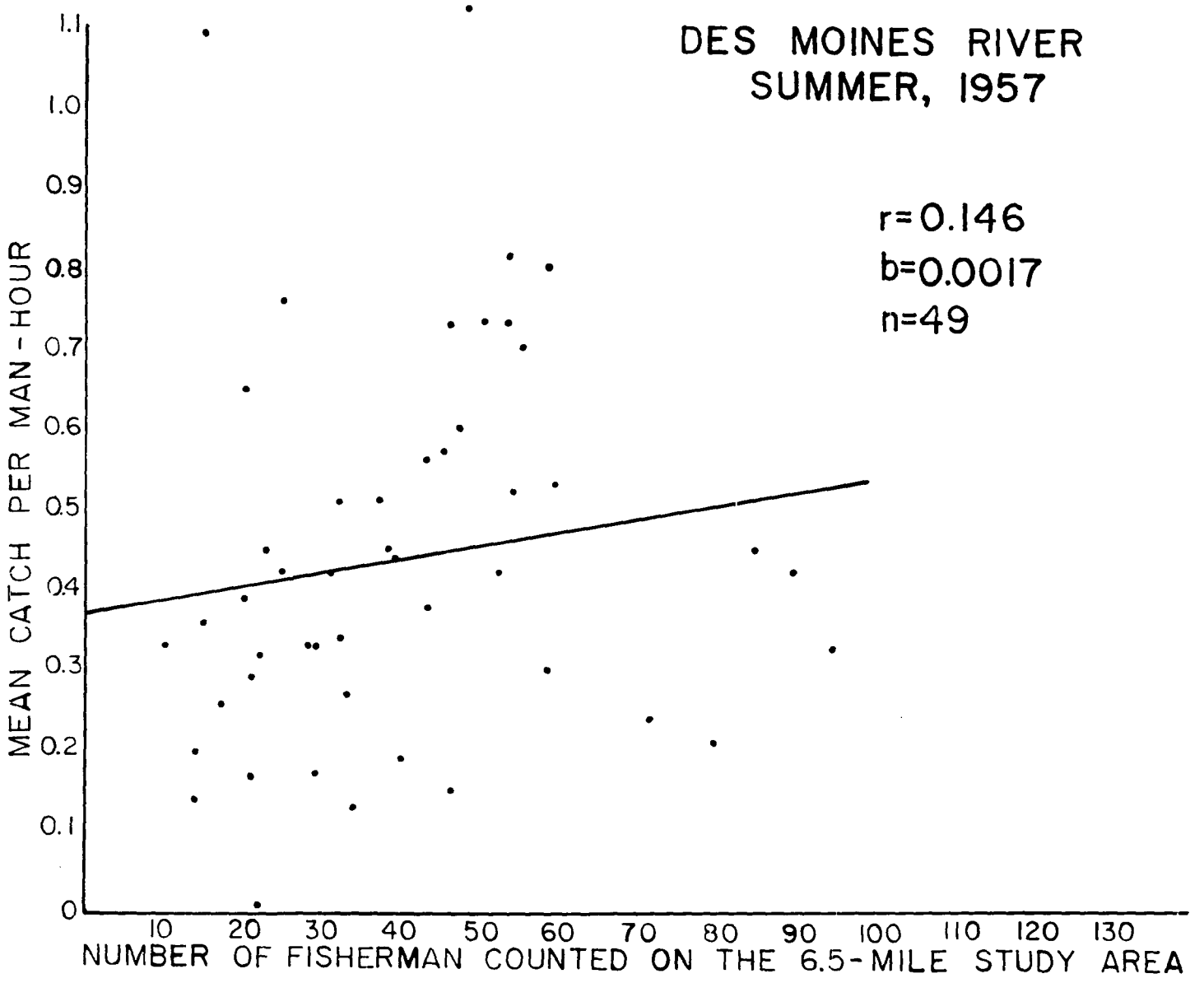
incompleted-fishing contacts might introduce errors in estimating the species composition of the catch but no analysis of the data was made checking this possibility. However, since there are only two or three important species in the Des Moines River fishery, it was believed that no serious error in estimating the species composition would arise from using incompleted-fishing contacts.

Relationship of Rate of Catch to Level of Fishing Pressure

In the Des Moines River creel surveys there was a tendency, as previously stated, to sample a large portion of the anglers on week days when fishing pressure was light and to sample a larger number but a smaller proportion of anglers on week-ends and holidays when fishing intensity was heavy. This tendency was not intentional but resulted simply because it was physically impossible for one person to contact the same proportion of anglers on heavily fished days as on lightly fished days.

To ascertain whether a serious bias would result from combining creel data from lightly fished and heavily fished days, the mean daily catch per man-hour was plotted against the number of anglers fishing on the study area for the 1957 summer data (Figure 5). The correlation coefficient, r, was 0.146 which is not statistically significant at the 95 percent probability level (r = 0.273; 50 d.f.). However, all

Figure 5. Relationship of mean rate of catch to the fishing pressure, Des Moines River, summer 1957.


DES MOINES RIVER
SUMMER, 1957
r=0.146
b=0.0017
n=49
MEAN CATCH PER MAN-HOUR
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
10 20 30 40 50 60 70 80 90 100 110 120 130
NUMBER OF FISHERMAN COUNTED ON THE 6.5-MILE STUDY AREA

the daily catch rates with more than 60 fishermen per 6.5 miles of river fell below the regression line. High levels of fishing intensity may have resulted in some interference with fishing success. For instance, the quality of fishing may have been directly affected because anglers competed with one another for the better sites. Also, family groups contributed heavily to the large counts and many were not seriously fishing but were merely on an outing. Conversely, family groups had a tendency to fish for the more easily caught species and kept many small fish. For the present it is assumed that there is no consistent relationship between fishing success and the amount of fishing pressure.

Distribution of fishing pressure

Certain areas along the 6.5-mile section of the Des Moines River were concentration points for fishermen. The easily accessible areas were the most popular fishing points in most instances, but in a few cases the availability of a certain species was responsible for heavy fishing pressure at a station. A total of 21 stations arbitrarily were assigned numbers (Figure 2). In interviewing anglers an attempt was made to census approximately the same percentage of anglers at all stations. From Table 2 it is evident that no serious bias was introduced into the results by censusing more anglers at a particular station than was justified by the distribution of all anglers. Station 1 (Fraser Dam) and

Table 2. Catch per man-hour, percentage of all fishermen counted, and percentage of all fishermen interviewed analyzed by stations during five seasons on a 6.5-mile section of the Des Moines River.

Station number	Percentage of all fishermen counted	Percentage of all fishermen interviewed	Catch per man-hour
1	23.1	23.5	0.37
2	0.4	0.2	0.17
3	2.2	1.6	0.29
4	1.7	1.5	0.29
5	0.5	0.2	0.63
6	0.1	0.1	1.05
8	0.2	0.1	0.0
9	3.4	3.6	0.35
10	8.8	9.1	0.37
11	3.6	4.1	0.23
12	1.4	1.2	0.37
13	1.1	0.8	0.36
14	0.6	0.3	0.26
15	2.5	1.9	0.36
16	4.2	4.5	0.73
17	3.6	3.6	0.42
18	7.2	6.8	0.71
19	4.8	2.9	0.41
20	24.0	26.5	0.26
21	6.6	7.6	0.31

station 20 (Boone Dam) were the favorite fishing sites of 23.1 and 24.0 percent of all anglers counted, respectively. These dams are readily accessible and provide much of the total catch of game fish. Generally, it is believed that dams, even lowhead dams such as those at Boone and Fraser, concentrate fish just below the spillway (Tarzwell, 1942;

Eschmeyer and Miller, 1949). The average or lower-than-average rate of catch at the Fraser and Boone dams (Stations 1 and 20) are indicative of the emphasis which is placed on the capture of game fish at these points.

Stations 10, 16, 18, and 19 were also popular fishing sites and were the primary sites where carp were creeled. These "carp holes", as they are called by the local gentry, generally exhibited higher catch per man-hour rates than the average station. Few fish other than carp were sought at these stations.

Precision of Estimated Rate of Catch in the Des Moines River Creel Survey

Analysis of variance is a convenient method of evaluating sampling errors. In the analysis of variance of the 1957 summer data (Table 3), the variance (mean squares) attributed to weeks, days of the week, and 2-hour periods of the day were tested to determine whether or not the differences between these sources of variation and that for the "error" term were statistically significant. Briefly, statistical significance was determined by the use of the F tests (variance ratios) which were derived as follows:

$$F = \frac{\text{Mean square to be tested}}{\text{Mean square error}}$$

The resulting F values, weeks = 1.76; days = 2.10 and periods = 1.82, were not significant at the 95 percent

Table 3. Analysis of variance of the catch per man-hour for all types of fishermen on a 6.5-mile section of the Des Moines River from July 7 to August 24, 1957[a].

Source of variation	Degrees of freedom	Sum of squares	Mean squares
Total	48	27,233	-
Weeks	6	4,476	746.0
Days	6	5,364	894.0
Periods	6	4,649	774.9
Error	30	12,744	424.8

Standard error of the sample mean $= \sqrt{\frac{424.8}{49}} = 0.03$

[a]All mean values were coded by multiplying by 100.

probability level ($F_{6,30}=2.42$). Consequently, during the period of time covered by the 1957 summer census there apparently was no significant difference in the rate of catch between weeks, days, or periods. The standard error of the mean (properly the standard deviation of the sample mean), 0.03 fish per man-hour, amounted to 6.7 percent of the mean rate of catch, 0.44 fish per man-hour. This low percentage of the average rate of catch indicates that the survey design used gave reliable estimates of the catch per man-hour.

The remaining seasonal schedules were not statistically analyzed because the design of these schedules was changed so that simple analysis of variance was not possible. The days of the week were not sampled equally and a difficult computational method based on multiple regression techniques is required for separating the variance terms. There is little reason to suspect that the rate of catch between days of the week would vary greatly during any season. It is possible, however, that the rate of catch could vary significantly between 2-hour periods in the day during other seasons. Also, in the spring and fall, greatly different atmospheric and water conditions between early and late weeks in the season undoubtedly affect the rate of catch. Consequently, seasonal schedules in the spring and fall of 1958 were devised to aid in minimizing bias which weekly variations in the catch per man-hour might introduce. The details of the seasonal schedules will be discussed more fully later. No attempt was made to minimize the possible variation in the rate of catch between 2-hour periods but future creel surveyors may increase the precision of their estimates through adequate censusing of the more heavily fishing periods.

Estimation of Total Fishing Pressure

Perhaps the most important aspect of creel censuses is the estimate of the total fishing pressure. These estimates

can be used to expand catch per unit of effort results into estimates of the total yield. They may be useful in formulating management plans, also.

Various techniques have been tried by workers in an effort to estimate fishing pressure. The best techniques are those which use a definite sampling scheme in counting anglers (DiCostanzo, 1956; Eschmeyer, 1942; Kathrein, 1953; Tarzwell and Miller, 1943; and others). On the Des Moines River estimates of the fishing pressure were based on angler counts made on certain days according to prearranged seasonal schedules, which will be discussed in detail later.

There are three major factors contributing to the variability of angler counts: time of the day; day of the week; and season of the year. The modified Latin-square design as used in the present study was designed to minimize the variation attributable to the above three factors. The three-way classification (i.e., weeks, days, and periods) and the Latin-square analysis of variance permits isolation of the differences between weeks, days, and hours of the day.

Assuming that the mean number of anglers per count was an unbiased estimate of the number of fishermen one might observe at any randomly selected period during the day, the total fishing pressure, in angler hours, was estimated as follows:

$$\text{total angler hours} = \bar{y}DH$$

where $\bar{y}$ is the average number of anglers observed; D, is the number of days in the census period; and H, the length of the fishing day in hours. A refinement of this technique was actually used in estimating the total fishing pressure for any particular season. The total amount of fisherman-hours for each day of the week (i.e., Monday, Tuesday, etc.) over the entire season were separately computed and then summed for the estimation of the total amount of pressure. The fishing day in the spring and summer seasons was considered to be 14 hours, from 6 a.m. to 8 p.m. In the fall the fishing day was 12 hours long, 7 a.m. to 7 p.m. A considerable amount of angling takes place outside these hours on the Des Moines River and no effort was made to include this segment of the fishing body in the present discussion. Night angling pressure will be discussed in a following section.

Precision attained

The sampling errors associated with angler counts for the 1957 summer season were evaluated with an analysis of variance technique (Table 4). Standard errors of the estimated total angler-hours were derived as follows:

$$S.E. = HD\sqrt{\frac{MSE}{n}}$$

where n is the number of observations, MSE is the error mean square, and H and D are as previously defined.

Table 4. Analysis of variance of angler counts for all types of fishermen on a 6.5-mile section of the Des Moines River, July 7 to August 25, 1957.

Source of variation	Degrees of freedom	Sum of squares	Mean squares
Total	48	19,617.68	-
Weeks	6	2,488.53	414.76
Days	6	8,828.53	1471.42
Periods	6	3,826.25	637.71
Error	30	4,474.37	149.15

Standard error of the sample mean $= \sqrt{\frac{149.15}{49}} = 1.75$

Insofar as sampling variation is concerned, the method described for deriving total amount of fishing pressure on the basis of angler counts appears to be sufficiently precise to permit its use in expanding sample estimates of catch per unit of effort and species composition of the catch into an appraisal of the total harvest. The sampling error of the total estimated fisherman-hours amounted to 1,196.86 hours, approximately 4.37 percent of the estimated total (Table 5). If sampling error were the only source of inaccuracies, estimates of the fishing pressure using a seasonal schedule similar to the one used in the summer of 1957

Table 5. Number of anglers per count (all fishermen combined), estimates of total angler-hours for the 1957 summer season, sampling error, and 95 percent confidence limits.

Length of season (days)	Mean number anglers per count	Estimated total fisherman-hours	Sampling error (hours)	95 percent confidence limits
49	39.9	27,384	1,196.86	24,976 - 29,792

would be in error (95 percent confidence interval) by not more than 9 percent. Of course, measures of sampling error do not indicate or detect bias of angler counts due to errors of angler response, errors of recording, etc. However, angler counts as taken in the Des Moines River creel survey are likely to result in an underestimation of the total angling pressure. DiCostanzo (1956), in the Clear Lake creel survey, used a similar creel survey and also believed that angler counts have a tendency to underestimate the quantity sought.

It was evident after applying the F tests to the mean squares of the variance terms (Table 4), that the angler counts in the summer of 1957 varied considerably between weeks, days and periods (F values for weeks = 2.78; days = 9.87; and periods = 4.28). All of these values are

statistically significant at the 95 percent probability level. In an effort to minimize some of the variability attributed to days of the week, the remaining seasonal schedules were designed so that Saturday and Sunday, the two most heavily fished days, were sampled more often than the weekdays. Also, in the spring and fall of 1958 an effort was made to minimize the variance between weeks by establishing additional strata. No attempt was made to minimize the variance of the 2-hour periods.

The establishment of a creel-census design is aided by previous knowledge of the fishery. If a creel census were to be conducted on a fishery similar to the Des Moines River fishery, the estimates of the total fishing pressure could be made more precise by deviating from the Latin-square design. For instance, it would be advisable to sample Saturdays, Sundays, and holidays more heavily than weekdays and the more heavily-fished 2-hour periods in the fishing day should be sampled more often than the lightly-fished periods. Also, some consideration should be given to the differential sampling of the more heavily-fished weeks or seasons. Admittedly a survey so designed would be difficult to analyze but, it would give more precise estimates of the total fishing pressure and catch per effort, which after all, are the main objectives of a creel survey.

STATISTICS OF THE FISHERY

The appraisal of the Des Moines River fishery was conducted on a seasonal basis, i.e., during the spring, summer, and fall. All seasons but the winter season were censused by a separate schedule which was modified to satisfy the special circumstances in each season. No winter censusing was done because few, if any, anglers tried fishing during winter. Each seasonal schedule was separately contrived and there was no interval between schedules. Although seasons and seasonal schedules were not identical, much of the data were combined because of the homogeneity of the characteristics of the Des Moines River fishery.

Periods Sampled in Each Census

In the summer of 1957, the creel-census study was initiated on the study area. The first censusing schedule was more or less an exploratory one since little was known about the Des Moines River fishery. A stratified sampling scheme similar to a Latin-square design was used to establish the schedule which extended from July 7 through August 24, 1957, a period of 49 days (Appendix, Table 38). The summer fishing day was considered to be 14 hours long, from 6 a.m. to 8 p.m. Each day was divided into seven 2-hour periods. Monday of each week was sampled at a different 2-hour period until all periods of the fishing day were censused. The

2-hour sampling periods were not selected in progressive order but all dates were selected at random within the sampling scheme. The remaining days of the week were sampled similarly. Also, seven daily samples were taken each week, each day in that week being censused at a different 2-hour period. Throughout the first four weeks of the census, counts of the fishermen were made with a boat. During the last three weeks of the census, an automobile was used to census the study area because the river was too shallow to traverse with the boat. A total of 1,163 anglers (59.5 percent of all the anglers counted) were interviewed during this period (Table 6). Approximately 14.3 percent of the total number of 2-hour periods in the entire season were censused.

During each of the seasonal schedules the 2-hour sampling period was used as the sampling unit. Spring and summer fishing days were considered to be 14 hours long, 6 a.m. to 8 p.m. The length of the fall fishing day was considered to be 12 hours, 7 a.m. to 7 p.m. (Table 6).

It was noticed in the first schedule that there was a great difference between the fishing pressure on weekdays and on week-end days. Therefore, the other schedules were separated into two divisions, a weekday and a week-end schedule. The number of days sampled per week was also reduced in these other schedules. In 1958 it was recognized

Table 6. Length and dates of each seasonal schedule, length of fishing day, percentage of the total number of 2-hour periods which were sampled, and percentage of all counted fishermen interviewed on a 6.5-mile section of the Des Moines River.

Season and dates	No. days in schedule	Length of fishing day censused	2-hour periods censused		Fishermen interviewed	
			No.	Percentage of all periods	No.	Percentage of all counted fishermen
Summer-1957 (July 7-Aug. 24)	49	6 a.m.-8 p.m.	49	14.3	1163	59.5
Fall-1957 (Aug. 25-Nov. 12)	80	7 a.m.-7 p.m.	25	5.2	413	73.4
Spring-1958 (Mar. 22-June 15)	86	6 a.m.-8 p.m.	35	5.8	633	69.0
Summer-1958 (June 16-Sept. 7)	85	6 a.m.-8 p.m.	37	6.2	782	79.5
Fall-1958 (Sept. 8-Nov. 16)	70	7 a.m.-7 p.m.	28	6.7	266	73.9

that the spring and fall seasons covered a period of time in which fishing pressure would be markedly different at the beginning and the end of the season. To compensate for any bias which might result from the chronological random selection of 2-hour sampling periods, the spring and fall seasons were divided into three strata (early, middle, and late). Every 2-hour period in the fishing day was sampled once in each stratum on weekdays.

The 80-day fall censusing schedule extended from August 25 to November 12 and was confluent with the completed summer schedule. The fall schedule was lengthened and modified so that fewer counts and interviews were completed each week than in the summer (Appendix, Table 39). The weekday schedule, Monday through Friday, was a modified Latin-square with each day of the week (i.e., Monday, Tuesday, etc.) being sampled three times. Since it was determined from the summer census that the fishing pressure during the middle of the day did not differ greatly from the late-morning or early-afternoon periods, the 11 a.m. to 1 p.m. period was not sampled. The mean number of angler-hours expended between 11 a.m. and 1 p.m. was estimated by summing the number of angler-hours expended in the adjacent 2-hour periods (9 to 11 a.m. and 1 to 3 p.m.) and then computing the average of this sum. Each of the five remaining 2-hour periods was sampled five times. Almost three-fourths of all the anglers

counted in the fall of 1957 were interviewed (Table 6). However, the reduced number of sampling dates resulted in a coverage of only 5.2 percent of the total number of sampling periods.

Following a period of inactivity over the winter, the censusing of fishermen resumed shortly after the ice completely left the river (Appendix, Table 40). The 86-day censusing schedule extended from March 22 to June 15, 1958 and included 35, 2-hour sampling dates. Approximately 6.9 percent of all the anglers counted in the spring were interviewed. The 35, 2-hour sampling periods comprised 5.8 percent of the total number of periods in the 86-day census (Table 6).

The design of the 1958 summer schedule was, in general, similar to the spring schedule (Appendix, Table 41). The schedule extended from June 16 to September 7, a period of 85 days, and was confluent with the completed spring schedule. Almost 80 percent of all the anglers counted were interviewed. This rather high rate of coverage may be attributed to reduced angling pressure in 1958 which afforded the census taker an opportunity to interview a high percentage of the anglers at each station. Censusing was conducted during 37 sampling periods which comprised 6.2 percent of the total number of periods in the seasonal census (Table 6).

Immediately following the summer season, a 70-day fall

schedule, extending from September 8 to November 16, was initiated (Appendix, Table 42). Of the fishermen counted, 73.9 percent were interviewed. A total of 28, 2-hour periods were censused and this sample comprised 6.7 percent of the total number of 2-hour periods in the seasonal census.

No seasonal schedule was identical and the percentage of the total number of angler-hours which were recorded in personal interviews each season also varied (Table 7). Nevertheless, it was felt that each seasonal schedule provided reliable estimates of the fishery statistics and their results were directly comparable. In general, most aspects

Table 7. Estimated total number of angler-hours expended and the percentage of all anglers who were interviewed during the five seasons on a 6.5-mile section of the Des Moines River.

Period	No. angler-hours recorded	Estimated total no. angler-hours	Coverage (%)
Summer-1957	2848.5	27,384	10.4
Fall-1957	865.25	19,762	4.4
Spring-1958	1354.75	27,636	4.9
Summer-1958	1732.75	30,278	5.7
Fall-1958	608.75	9,768	6.2

of the fishery were similar from season to season and year to year. One important difference between the seasonal schedules in 1957 and 1958 was the length of the seasons. In the summer of 1957 the Latin-square design determined the length of the seasonal censuses. However, in 1958 the sampling was improved by defining the seasons more precisely rather than letting the Latin-square design determine the length of the season.

Knowledge of the fishery gained in 1957 indicated that the character of the fishery changed with the availability of certain species of fish, the caprice of the angler, and the weather conditions. The spring season begins shortly after the ice completely leaves the river. This time will vary but normally occurs in March. The spring season terminates when the channel catfish become active preparatory to spawning. This phenomenon usually occurs around the middle of June. The summer season lasts from mid-June until after approximately the first week in September. Iowa has experienced several cool mornings and evenings by this time of the year. After the first week in September channel catfish are no longer readily caught and game fish (especially walleyes) are the most important fish sought. Also, most fishermen have taken their annual vacations and the children have returned to school. The length of the fall season is determined by the weather conditions and the whims of the

anglers. Although the river does not usually freeze until after Christmas, most anglers on the Des Moines River abandon their sport by the middle of November.

Daily Fishing Pressure

Throughout all seasons of the year the week-end fishing pressure was heavier than on weekdays (Figure 6 and Table 8). Sunday was consistently the most heavily fished day and, during most seasons, Saturday was the next most heavily utilized day. Heavy utilization of week-end days by fishermen was expected since week-end days are the only times when many anglers have an opportunity to fish. Eschmeyer (1942), Houser and Heard (1958), Smith (1950) and many others have reported much greater fishing intensity on Saturdays and Sundays than during the week. Much of the heavy week-end fishing pressure on the Des Moines River was due to the presence of family groups who were on a combined outing and fishing trip. The family groups often failed to add appreciably to the catch, however.

There was little difference between the fishing pressure on various weekdays (Table 8). There was a tendency, however, during some seasons (Summer-1957; Fall-1958) for fishing pressure to be lower on Mondays and Fridays which probably was caused by the proximity of the week-end.

In the fall of 1957, Tuesday and Friday, with mean

Figure 6. Mean fishing pressure expended during five seasons on a 6.5-mile section of the Des Moines River on various days of the week.

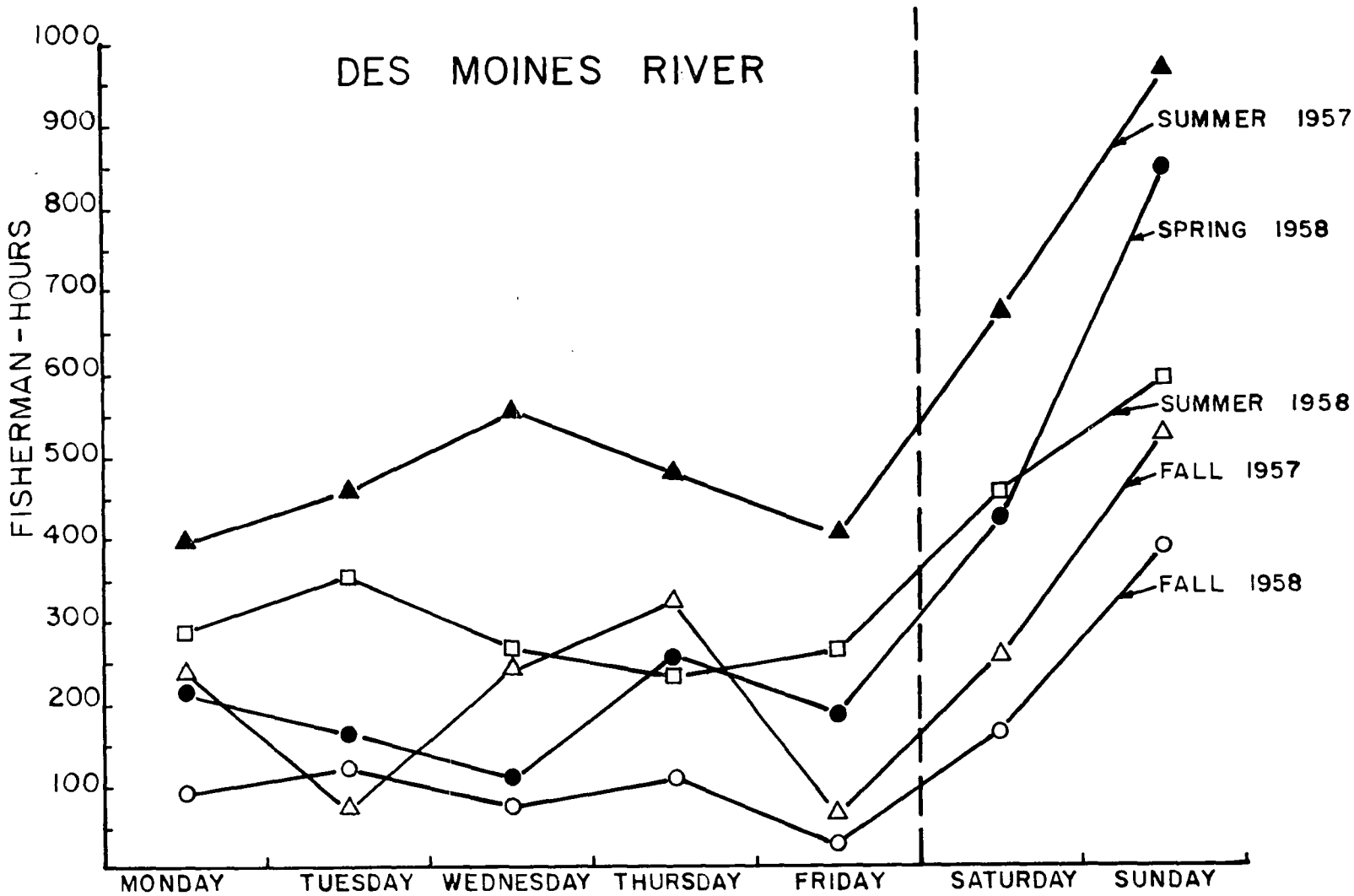

DES MOINES RIVER
FISHERMAN-HOURS
1000
900
800
700
600
500
400
300
200
100
MONDAY
TUESDAY
WEDNESDAY
THURSDAY
FRIDAY
SATURDAY
SUNDAY
SUMMER 1957
SPRING 1958
SUMMER 1958
FALL 1957
FALL 1958

Table 8. Mean number of fisherman-hours expended each day of the week during five seasons on a 6.5-mile section of the Des Moines River. Numbers in parentheses indicate the number of angler counts made on each day of the week.

Season	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Totals
Summer 1957	967.4 (7)	397.6 (7)	457.8 (7)	551.6 (7)	477.4 (7)	404.6 (7)	672.0 (7)	3928.4 (49)
Fall 1957	525.6 (5)	236.4 (3)	72.0 (3)	240.0 (3)	320.4 (3)	63.6 (3)	254.5 (5)	1712.4 (25)
Spring 1958	849.8 (7)	212.8 (5)	161.0 (4)	105.0 (4)	254.8 (4)	186.2 (4)	424.2 (7)	2193.8 (35)
Summer 1958	592.2 (7)	284.2 (4)	352.8 (5)	266.0 (5)	231.0 (5)	263.2 (5)	452.2 (6)	2441.6 (37)
Fall 1958	391.2 (5)	90.0 (4)	120.0 (3)	74.4 (4)	108.0 (4)	27.6 (3)	165.6 (5)	976.8 (28)

values of 72.0 and 63.6 fisherman-hours respectively, received the least amount of fishing pressure. However, the differences between weekday counts may be attributed largely to weather conditions and to the fall sampling scheme which failed to take in account marked changes in the fall weather. For instance, all of the sampling dates on Tuesday, even though randomly selected, occurred in the last one-half of the season when fishing pressure was lighter. In both fall seasons angling pressure on Saturday was slightly higher than the average amount of angling pressure exerted on most weekdays.

Although summer fishing was not affected greatly by uncomfortable weather conditions, fall weather conditions did affect angling pressure. Inclement weather on two occasions caused all fishermen to abandon their sport. In late August and early September family groups who were both picnicing and fishing swelled the fisherman counts. As the season progressed the mean number of anglers counted at any one time decreased and, late in the season, only the hardy walleye fishermen were present.

Adverse early spring weather also affected angling pressure and on one date no anglers were sighted. However, the renewal of the desire to go fishing after the long winter did tend to counterbalance some of the depressing effects of poor weather conditions. The bulk of the fishing

early in the spring was furnished by experienced fishermen. As the weather grew warmer, family groups and the "occasional" angler swelled the fisherman counts. On one Sunday between the hours of 2 and 4 p.m., 137 fishermen were counted on the study area.

Hourly Fishing Pressure

The distribution of fishing intensity during any day followed a definite pattern according to the season of the year (Figure 7 and Table 9). In the summer, fishing pressure gradually increased as the day progressed and reached its highest point in the late-evening period, 6 to 8 p.m. However, during the hours of 4 to 6 p.m. many fishermen evidently returned home for supper or to do chores, resulting in a slightly lower mean count than the preceding and succeeding 2-hour periods. The heavy evening fishing pressure during the 6 to 8 p.m. period probably can be attributed to many fishermen who fished for a few hours after work. Since most of the river is easily accessible to automobiles, it is a simple matter to motor to the river for an evening of fishing. Although the early-morning period had fewer anglers than any other period, many of these anglers were experienced and competent fishermen.

Fishing intensity during the fall seasons reached its highest point in the late-afternoon period, 3 to 5 p.m.,

Figure 7. Mean fishing pressure expended during five seasons on a 6.5-mile section of the Des Moines River at various hours of the day.

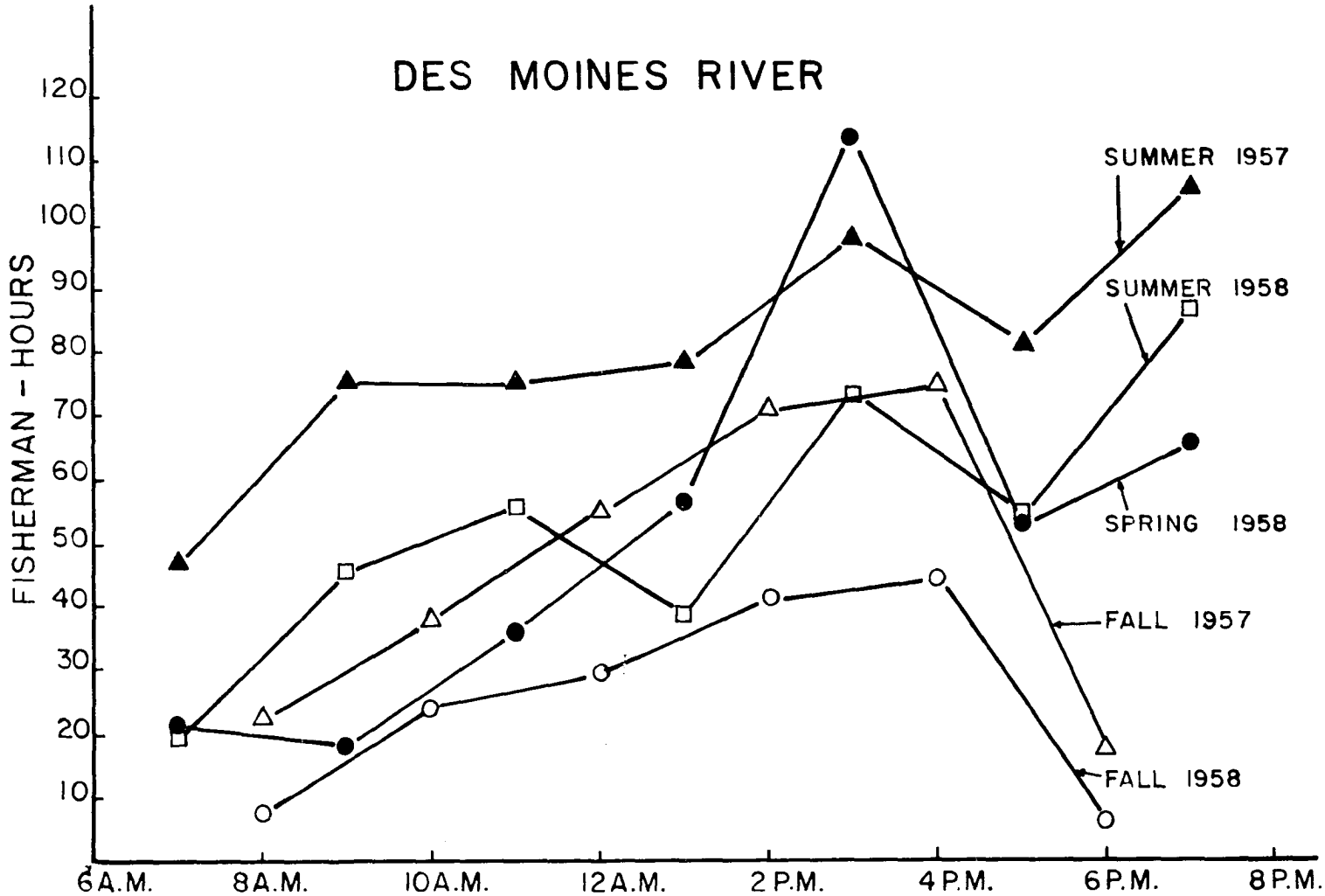

DES MOINES RIVER
FISHERMAN - HOURS
120
110
100
90
80
70
60
50
40
30
20
10
6A.M.
8A.M.
10A.M.
12A.M.
2P.M.
4P.M.
6P.M.
8P.M.
SUMMER 1957
SUMMER 1958
SPRING 1958
FALL 1957
FALL 1958

Table 9. Mean number of fisherman-hours expended each 2-hour sampling period during five seasons on a 6.5-mile section of the Des Moines River. Numbers in parentheses indicate the number of angler counts made during each 2-hour period.

Season	6-8 a.m.	7-9 a.m.	8-10 a.m.	9-11 a.m.	10-12 a.m.	11 a.m. 1 p.m.	12-2 p.m.	1-3 p.m.	2-4 p.m.	3-5 p.m.	4-6 p.m.	5-7 p.m.	6-8 p.m.	Totals
Summer-1957	47.8 (7)		76.2 (7)		75.4 (7)		78.6 (7)		98.4 (7)		81.0 (7)		106.2 (7)	563.6 (49)
Fall-1957		22.8 (5)		38.0 (5)		54.8[a]		70.8 (5)		74.8 (5)		16.8 (5)		278.0 (25)
Spring-1958	20.8 (5)		18.4 (5)		36.4 (5)		56.8 (5)		114.4 (5)		52.8 (5)		66.8 (5)	366.4 (35)
Summer-1958	19.6 (6)		45.6 (5)		56.0 (4)		38.8 (5)		73.4 (6)		53.4 (6)		87.2 (5)	374.0 (37)
Fall-1958		7.6 (5)		24.8 (5)		29.6 (5)		41.0 (4)		44.0 (5)		6.4 (4)		153.4 (28)

[a]This figure is an estimate derived by averaging the counts of the adjacent 2-hour periods.

which normally coincided with the warmest part of the day. Fall fishing pressure was very light during the early-morning and late-evening periods. Evidently the cool morning and evening temperatures discouraged many anglers. Also, it began to get dark before the end of the 5 to 7 p.m. period, especially late in the fall.

The spring season displayed a fishing intensity pattern which combined features of both the summer and the fall seasons. The peak of the spring fishing pressure occurred in the mid-afternoon period, 2 to 4 p.m., but the second most popular fishing time was the late-evening period, 6 to 8 p.m.

The hourly distribution of angling pressure on weekdays displayed a different pattern from that observed on week-end days (Table 10). A higher percentage of the week-end anglers fished the early-morning 2-hour period. Evidently the week-end anglers were eager to get an early start on their day off from work. A greater percentage of the weekday anglers fished in the late-evening 2-hour period than did their week-end counterparts, primarily due to the large number of anglers who fished after work during the week.

Chi-square tests were computed for each season testing whether or not there was a statistical difference between hourly distribution of fishing pressure on weekdays and week-end days. The resulting chi-square values were as

Table 10. A comparison between the hourly distribution of fishing pressure on weekdays and week-end days during five seasons on a 6.5-mile section of the Des Moines River. All figures are expressed as percentages of the total number of anglers counted who fished on either weekdays or week-end days.

	6-8 a.m.	7-9 a.m.	8-10 a.m.	9-11 a.m.	10-12 a.m.	11 a.m. 1 p.m.	12-2 p.m.	1-3 p.m.	2-4 p.m.	3-5 p.m.	4-6 p.m.	5-7 p.m.	6-8 p.m.
Summer-1957													
Weekdays	7.5		12.7		11.6		12.6		18.0		13.7		24.0
Week-end days	9.8		15.0		16.1		16.1		18.1		13.6		11.5
Fall-1957													
Weekdays		5.9		6.9		23.0		39.3		18.4		6.6	
Week-end days		10.0		19.4		16.9		14.6		33.5		5.6	
Spring-1958													
Weekdays	4.3		7.6		11.2		6.8		25.9		18.7		25.5
Week-end days	6.3		3.9		9.4		19.3		33.5		12.5		15.0
Summer-1958													
Weekdays	2.5		4.2		14.8		14.5		23.1		15.0		25.9
Week-end days	8.2		17.9		17.9		6.3		16.2		13.6		19.9
Fall-1958													
Weekdays		7.0		19.5		3.9		31.3		28.1		10.2	
Week-end days		3.6		13.5		25.2		30.7		27.0		-	

follows: Summer-1957, $x^2 = 6.13$ (d.f. = 6); Fall-1957, $x^2 = 23.65$ (d.f. = 5); Spring-1958, $x^2 = 12.68$ (d.f. = 6); Summer-1958, $x^2 = 16.82$ (d.f. = 6); and Fall-1958, $x^2 = 27.95$ (d.f. = 5). In all seasons but one (Summer-1957) the resulting chi-square values were significant at the 95 percent probability level. The values were highly significant in the fall seasons while in the spring of 1958 the appropriate chi-square value was just barely significant. These significant chi-square values indicate that there was a true difference between the distribution of weekday and week-end day hourly fishing pressure.

Total Fishing Pressure

The total fishing pressure was estimated by multiplying the mean number of fisherman-hours expended each day of the week (i.e., Monday, Tuesday, etc.) by the number of Mondays, Tuesday, etc. in the census and then summing the total number of hours for each day of the week. The total estimates for each season are given in Table 11. The night fishing effort was not included.

The amount of fishing pressure expended each week during the summer of 1958 (2,442 fisherman-hours) was only about 60 percent of that expended during the summer of 1957 (3,928.4 fisherman-hours). Most of this reduction probably was due to the frequent rains and several short sieges of

Table 11. Estimates of the total number fisherman-hours, fisherman-hours per week, fisherman-hours per week per mile, and fisherman-hours per week per acre during five seasons on a 6.5-mile section of the Des Moines River.

Season	Estimated total no. fisherman-hrs.	Fisherman-hours/ week	Fisherman-hours/ week/mile	Fisherman-hours/ week/acre	Ave. length of fishing trip (hrs.)
Summer-1957	27,384	3,912	601.8	21.9	4.9
Fall-1957	19,762	1,712	263.4	9.6	4.2
Spring-1958	27,636	2,194	337.5	12.3	4.3
Summer-1958	30,278	2,442	375.7	13.6	4.4
Fall-1958	9,768	977	150.3	5.5	4.6

high water which occurred in July. The month of July, with over 10 inches of rainfall, surpassed all previous weather bureau rainfall records for that month. Since July is a heavily fished month, especially for those anglers seeking channel catfish, unstable water levels and frequent flash floods were certain to have a depressing effect on the total fishing pressure.

In comparison with the fall of 1957, angling pressure was approximately 43 percent less in 1958 than it was in 1957. This moderate amount of fishing pressure in 1958 can be attributed to the poor creel success of fall anglers.

If it is assumed that on the average a fisherman was contacted when one-half of his fishing trip was completed, the average length of a fishing trip ranged between 4.2 and 4.9 hours (Table 11).

In 1958, the only year which was censused completely, there were approximately 67,682 fisherman-hours expended on the 6.5-mile section of the Des Moines River. This amounts to an average of 10,412 fisherman-hours per mile or 378.1 fisherman-hours per acre per year. Also, 1958 was a poor fishing year and absorbed less fishing pressure than did 1957. During an average year the total daylight fishing pressure could be expected to amount to between 65,000 and 85,000 fisherman-hours which would be equivalent to 10,000 to 13,077 fisherman-hours per mile or 363 to 475 fisherman-

hours per acre.

There are only a few studies on warm-water streams which have quantitatively measured the fishing pressure. The results of some of these studies and of a few trout stream investigations are compared with the Des Moines River fishery in Table 12. The term "fisherman-day" as used in the table is defined as one day of fishing by an individual fisherman irrespective of the number of hours involved. Assuming that the average fishing trip of the Des Moines River angler was 4.5 hours, then the Des Moines River in the study area averaged between 2,222 and 2,906 fisherman-days per mile per year.

A small one and three-fourths of a mile section of Medicine Creek in Nebraska was the only stream estimated to have absorbed more fishing pressure per mile (2,857 fisherman-days) than the Des Moines River. However, this section of Medicine Creek actually constituted the tailwaters of the Harry Strunk Lake dam and must be considered atypical for a stream. The Republican River in Nebraska and Kansas, a river similar to the Des Moines River, averaged 405 fisherman-days per mile of stream. The Madison River in Montana and the Pigeon River in Michigan, two heavily fished trout streams, averaged 231 and 590 fisherman-days per mile respectively.

Many studies have attempted estimates of the total

Table 12. A comparison of the fishing pressure on some selected streams in the United States.

Stream	Distance covered	Period covered	Fisherman-days/mile	Investigator
Rush Creek California	3.7 miles	6 mos. per year. 1947-1951	1,800	Vestal, 1954
Des Moines River Iowa	6.5 miles	March 22 - Nov. 16, 1958	2,314	Present study
Potomac River Maryland	170 miles	6 mos. June - Oct. 1954	520	Elser, 1954
Pigeon River Michigan	4.8 miles	4 mos. 1951	590	Cooper, 1953
Big Piney River Missouri	82 miles	All season 1953	432	Fleener, 1952
Niangua River Missouri	81 miles	All season 1953	273	Fleener, 1952
Madison River Montana	98 miles	5 mos. per year. 1950-1953	231	U.S. Fish and Wildl. Serv., 1954
Medicine Creek Nebraska	1.75 miles	1951	2,857	Nicholson and Borges, 1955
Republican River Nebraska & Kansas	43 miles	1951	405	Nicholson and Borges, 1955

fishing pressure on large lakes and reservoirs (Eschmeyer, 1936, 1939; Kathrein, 1953; Mraz and Threinen, 1956; Tarzwell and Miller, 1943). However, the Des Moines River apparently provides more hours of fishing per acre than most lakes and reservoirs.

Catch per Man-Hour

The success of the Des Moines River angler during the course of this study was quite poor. A summary of the catch per man-hour for all types of fishermen during all seasons censused is given in Table 13. The rate of catch and species composition of the catch for each season are given in Tables 14, 15, 16, 17, and 18. In general, a rate of catch of one fish per hour is considered to be a good rate of catch. Anglers on the Des Moines River averaged only 0.38 fish per man-hour during all seasons. This rate of catch is slightly lower than that reported by Greenbank (1957) for the upper Mississippi River and lower than the majority of the studies of warm-water streams listed by Carlander (1953).

Boat anglers enjoyed the highest catch per man-hour, 0.49 fish. The boat angler's higher rate of catch can be attributed to their ability to effectively cover more area. Also, a higher percentage of the boat anglers were experienced river anglers. Many other studies have observed that boat anglers enjoyed the best success of all types of

Table 13. Mean catch per man-hour for all types of anglers during five seasons on a 6.5-mile section of the Des Moines River.

Season	Boat	Shore	Waders	Mean
Summer-1957	0.60	0.45	0.34	0.45
Fall-1957	0.47	0.29	0.15	0.28
Spring-1958	0.34	0.29	0.57	0.31
Summer-1958	0.50	0.39	0.23	0.40
Fall-1958	0.35	0.20	0.20	0.21
Mean	0.49	0.37	0.28	0.38

Table 14. Catch per unit effort and percentage composition of catches recorded on a 6.5-mile section of the Des Moines River, July 7 to August 24, 1957.

	Boat	Shore	Waders	Total
No. anglers counted	139	1,580	237	1,956
No. anglers contacted	88	926	149	1,163
Fisherman-hours	271.0	2,152.5	425.0	4,776.75[a]
No. fish caught	163	977	146	2,156[a]
Catch per man-hour	0.60	0.45	0.34	0.45
		Percent		
Channel catfish	68.1	40.5	63.0	46.6
Carp	31.9	47.8	13.7	41.9
Walleye	-	3.9	6.9	3.7
Smallmouth bass	-	1.6	4.1	1.6
Flathead catfish	-	0.8	2.7	0.9
Bullheads	-	3.6	7.5	3.6
Suckers	-	1.1	0.7	0.9
Others[b]	-	0.7	1.4	0.7

[a]Adjusted to the total number of anglers counted.

[b]Includes crappie, rock bass, and stonecats.

Table 15. Catch per unit effort and percentage composition of catches recorded on a 6.5-mile section of the Des Moines River, August 25 to November 12, 1957.

	Boat	Shore	Waders	Total
No. anglers counted	30	465	65	560
No. anglers contacted	14	345	54	413
Fisherman-hours	23.5	724.5	117.25	1,168[a]
No. fish caught	11	209	18	328[a]
Catch per man-hour	0.47	0.29	0.15	0.28
		Percent		
Channel catfish	81.8	31.0	47.8	35.0
Carp	-	44.3	-	38.0
Walleye	18.2	15.3	26.2	16.5
Smallmouth bass	-	2.5	8.7	3.0
Flathead catfish	-	2.0	4.3	2.1
Bullheads	-	1.0	-	0.8
Suckers	-	3.9	4.3	3.8
Others[b]	-	-	8.7	0.8

[a]Adjusted to the total number of anglers counted.

[b]Crappie was the only species taken in the fall.

fishermen (Carter, 1957; Smith, 1950; and others). On the other hand, Tarzwell (1942) found that on T.V.A. lakes the average catch per hour of bank fishermen was twice as great as that for boat fishermen. This was due largely to the abundance of carp in the bank angler's creel.

Waders in the Des Moines River displayed the poorest catch rate with an average of 0.28 fish per man-hour. In the spring of 1958, waders had the highest rate of catch with a mean of 0.56 fish per hour but, compared to other seasons, there was little wading done and the sample of

Table 16. Catch per unit effort and percentage composition of catches recorded on a 6.5-mile section of the Des Moines River, March 22 to June 15, 1958

	Boat	Shore	Waders	Total
No. anglers counted	52	818	46	916
No. anglers contacted	27	585	21	633
Fisherman-hours	93.5	1,216	45.25	1,979.5[a]
No. fish caught	32	354	26	614[a]
Catch per man-hour	0.34	0.29	0.57	0.31
		Percent		
Channel catfish	31.2	34.7	70.4	37.9
Carp	25.0	40.6	-	35.4
Walleye	-	3.7	7.4	3.7
Smallmouth bass	-	1.7	11.1	2.2
Flathead catfish	-	2.0	7.4	2.3
Bullheads	-	0.6	3.7	0.8
Suckers	43.8	15.3	-	16.5
Others[b]	-	1.4	-	1.2

[a]Adjusted to the total number of anglers counted.

[b]Includes crappie and buffalo.

waders was small. Many waders actually were competent anglers who only fished for channel catfish and game fish. Waders in other bodies of water often are very successful and in Clear Lake, Iowa, enjoyed the highest catch per man-hour of all fisherman types (DiCostanzo and Ridenhour, 1957).

Included in the shore fishermen were many novice and inexperienced anglers. Small channel catfish and carp comprised much of their catch. During August, shore anglers

Table 17. Catch per unit effort and percentage composition of catches recorded on a 6.5-mile section of the Des Moines River, June 16 to September 7, 1958.

	Boat	Shore	Waders	Total
No. anglers counted	100	806	74	980
No. anglers contacted	69	664	49	782
Fisherman-hours	209.25	1,414.0	110	2,185.5[a]
No. fish caught	104	557	25	865[a]
Catch per man-hour	0.50	0.39	0.23	0.40
		Percent		
Channel catfish	45.6	25.0	40.0	29.4
Carp	52.4	58.8	36.0	57.0
Walleye	1.0	3.6	20.0	3.8
Smallmouth bass	-	1.6	-	1.3
Flathead catfish	1.0	0.9	-	0.9
Bullheads	-	3.9	4.0	3.4
Suckers	-	4.7	-	3.8
Others[b]	-	0.5	-	0.4

[a]Adjusted to the total number of anglers counted.

[b]Includes crappie and buffalo.

relied heavily upon carp ranging from 8 to 10 inches in total length to fill their creel.

Number of unsuccessful fishermen

It was difficult to determine the number of unsuccessful fishermen since all the data were recorded by interviewing fishermen parties. A successful fishing party was considered to be any party of anglers who had caught at least one fish. However, there were many fishermen in successful fishing parties who failed to catch fish and all

Table 18. Catch per unit effort and percentage composition of catches recorded on a 6.5-mile section of the Des Moines River, September 8 to November 16, 1958.

	Boat	Shore	Waders	Total
No. anglers counted	23	301	36	360
No. anglers contacted	11	223	32	266
Fisherman-hours	31.5	474	103.25	821.75[a]
No. fish caught	11	93	21	173[a]
Catch per man-hour	0.35	0.20	0.20	0.21
		Percent		
Channel catfish	36.4	15.0	55.0	23.0
Carp	63.6	62.4	5.0	53.3
Walleye	-	6.5	35.0	11.1
Smallmouth bass	-	1.1	-	0.8
Flathead catfish	-	2.1	5.0	2.4
Bullheads	-	2.1	-	1.6
Suckers	-	9.7	-	7.1
Others[b]	-	1.1	-	0.8

[a]Adjusted to the total number of anglers counted.

[b]Includes crappie and buffalo.

estimates given below should be regarded as minimum estimates. Approximately 58 percent of all fishermen were unsuccessful in their attempts to catch fish. Of those fishermen who had completed their fishing trip, 45 percent were unsuccessful. Of those fishermen who were interviewed while in the act of fishing, 59.1 percent were unsuccessful. These minimum percentages appear to be about average when compared to other studies. King and Currier [*ca.* 1951], working on the Little River in Tennessee, found that

approximately one-third of all the anglers caught no fish. Van Meter (1954) and Trembley (1954), working in West Virginia and Pennsylvania, respectively, found that approximately one-half of all anglers were unsuccessful. Clark et al. (1948), working on Lake St. Mary in Ohio, and Rupp (1955), on the Sunkhaze Stream in Maine, interviewed rather high numbers of unsuccessful anglers, 64 and 69 percent, respectively.

Rate of catch with respect to time of day and fishing pressure

Except for the fall of 1957 (Figure 9), the catch per man-hour appears to be higher in the late afternoon than at other time of the day (Figures 8, 10, 11 and 12). The early-morning anglers concentrated their efforts on the more difficult species to catch and consequently had a much lower catch per man-hour. In the summer of 1957, anglers fishing in the 6 to 8 a.m. period caught a total of 132 fish of which 76.5 percent were channel catfish. Also, approximately 55.6 percent of the fish caught between 8 to 10 a.m. were channel catfish. Carp, a more easily caught species, comprised 77.6 percent of all fish caught in the 6 to 8 p.m. period and 64.8 percent of all fish caught between 4 and 6 p.m.

In the spring of 1958 (Figure 10) the catch per man-hour was lower in the late evening than at any other time

Figure 8. Fishing pressure and catch per man-hour at different times of the day in a 6.5-mile section of the Des Moines River, July 7 to August 24, 1957.

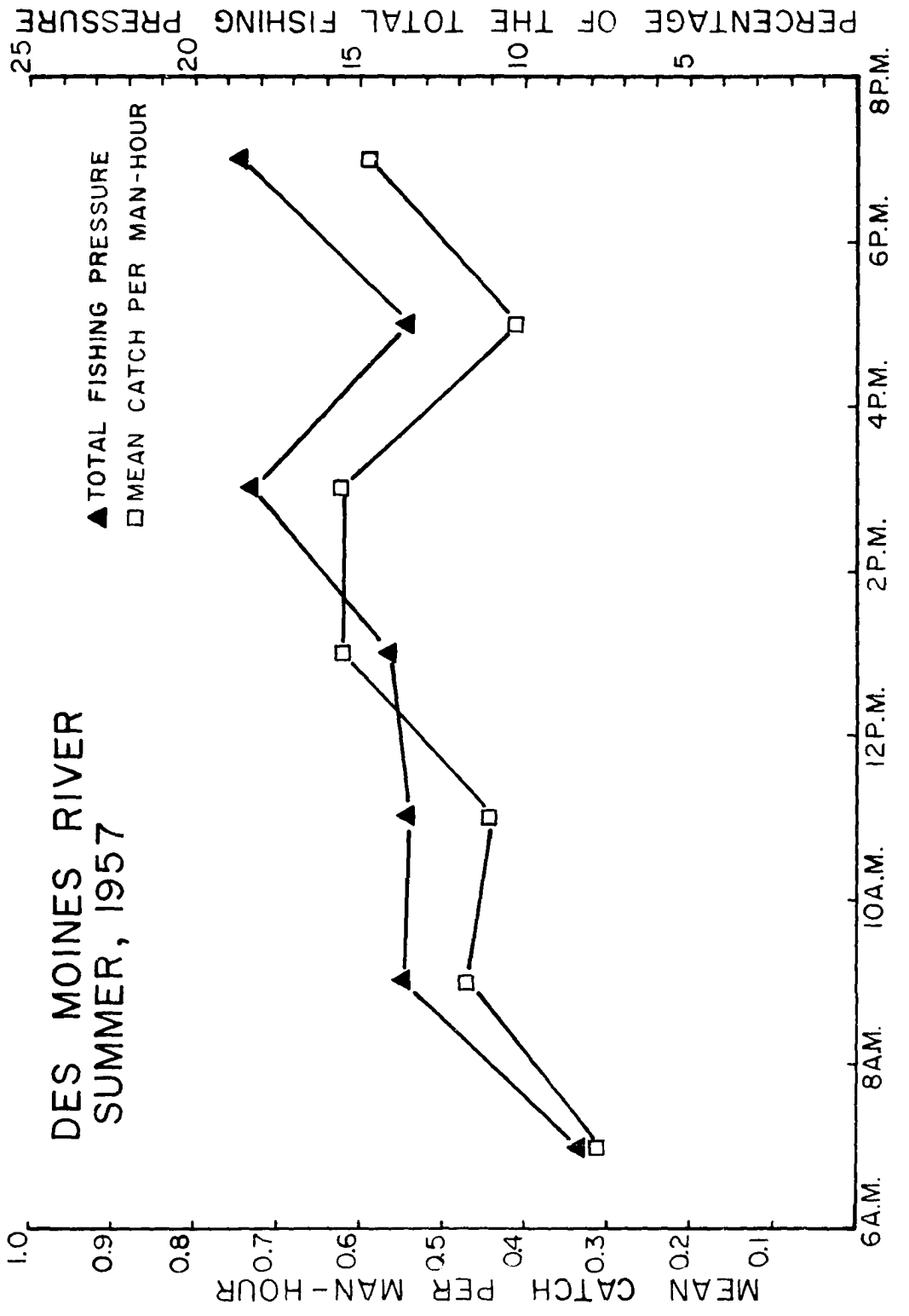

DES MOINES RIVER
SUMMER, 1957
TOTAL FISHING PRESSURE
MEAN CATCH PER MAN-HOUR
MEAN CATCH PER MAN-HOUR
PERCENTAGE OF THE TOTAL FISHING PRESSURE
6A.M.
8A.M.
10A.M.
12P.M.
2P.M.
4P.M.
6P.M.
8P.M.
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
25
20
15
10
5

Figure 9. Fishing pressure and catch per man-hour at different times of the day in a 6.5-mile section of the Des Moines River, August 25 to November 12, 1957.

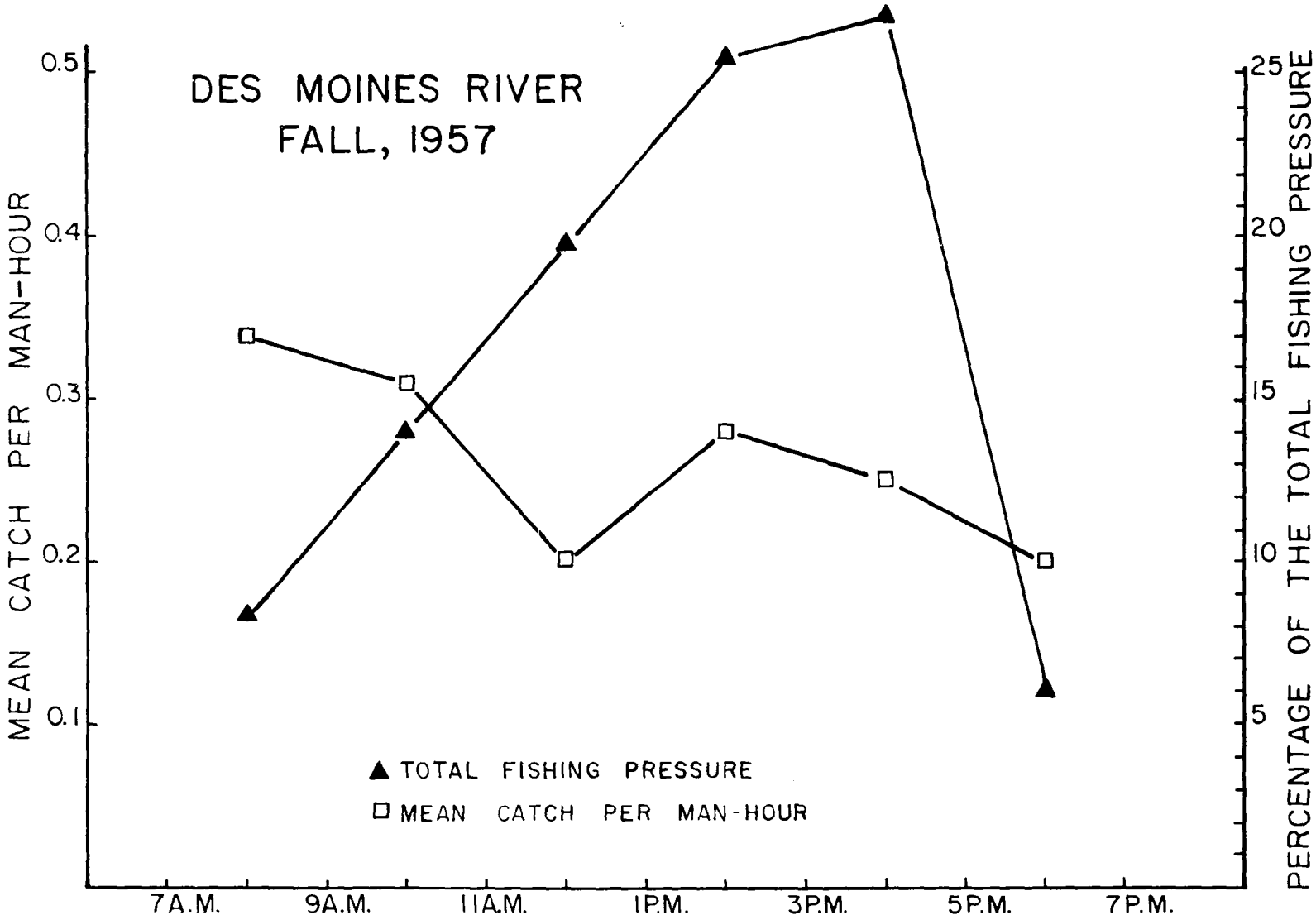

DES MOINES RIVER
FALL, 1957
MEAN CATCH PER MAN-HOUR
0.5
0.4
0.3
0.2
0.1
PERCENTAGE OF THE TOTAL FISHING PRESSURE
25
20
15
10
5
7A.M.
9A.M.
11A.M.
1P.M.
3P.M.
5P.M.
7P.M.
TOTAL FISHING PRESSURE
MEAN CATCH PER MAN-HOUR

Figure 10. Fishing pressure and catch per man-hour at different times of the day in a 6.5-mile section of the Des Moines River, March 22 to June 15, 1958.

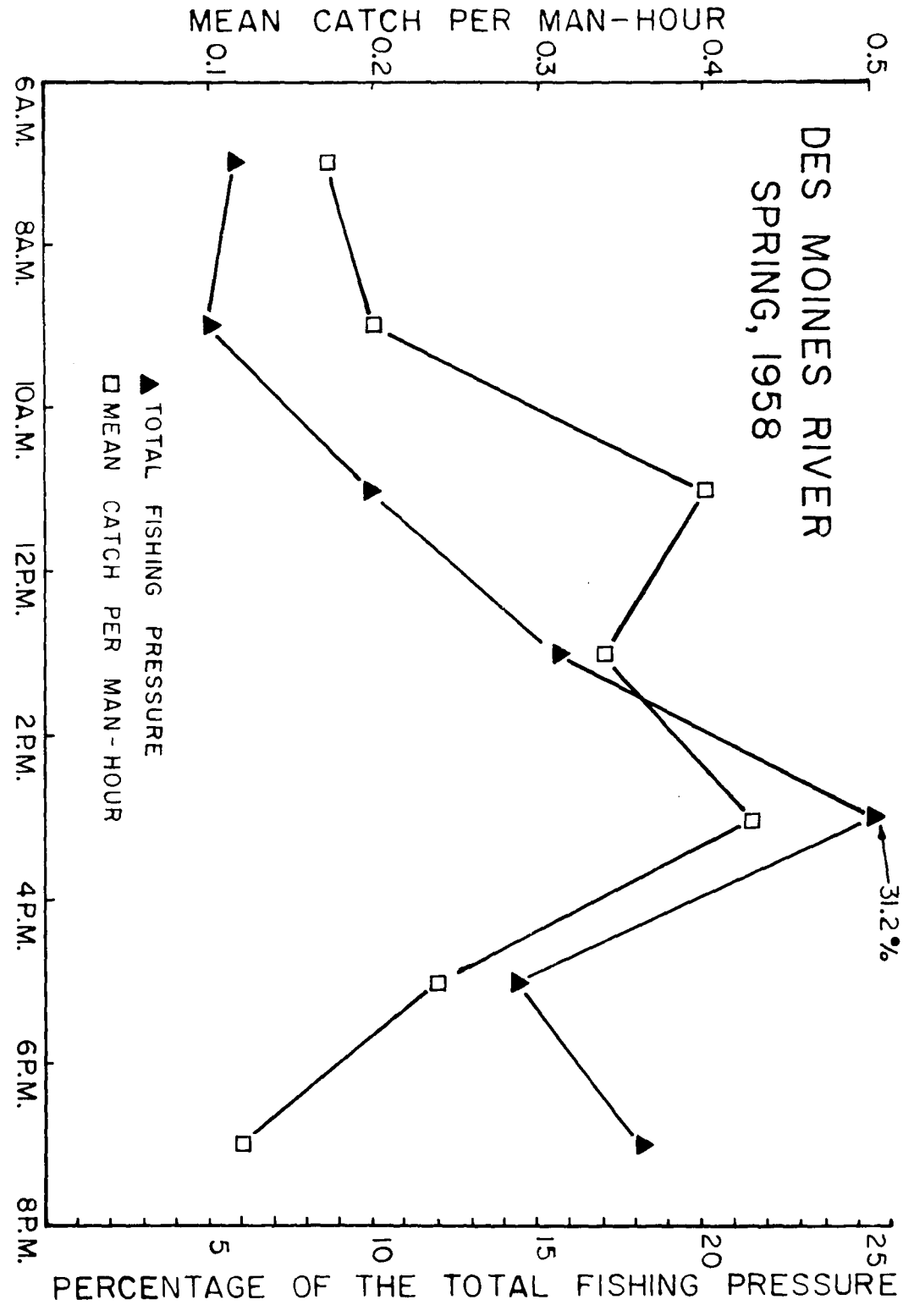

DES MOINES RIVER
SPRING, 1958
MEAN CATCH PER MAN-HOUR
0.1
0.2
0.3
0.4
0.5
6A.M.
8A.M.
10A.M.
12P.M.
2P.M.
4P.M.
6P.M.
8P.M.
TOTAL FISHING PRESSURE
MEAN CATCH PER MAN-HOUR
31.2%
5
10
15
20
25
PERCENTAGE OF THE TOTAL FISHING PRESSURE

Figure 11. Fishing pressure and catch per man-hour at different times of the day in a 6.5-mile section of the Des Moines River, June 16 to September 7, 1958.

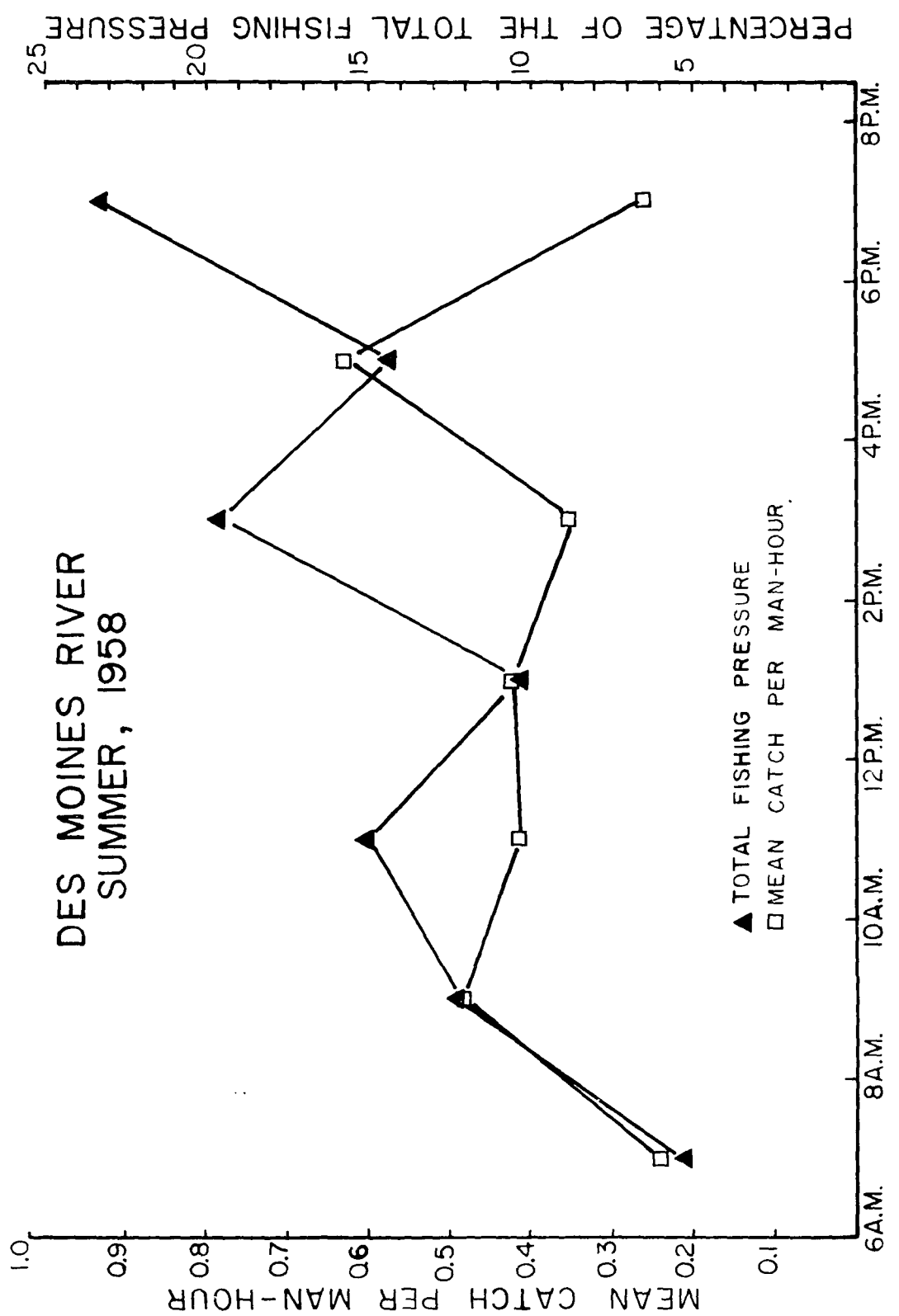
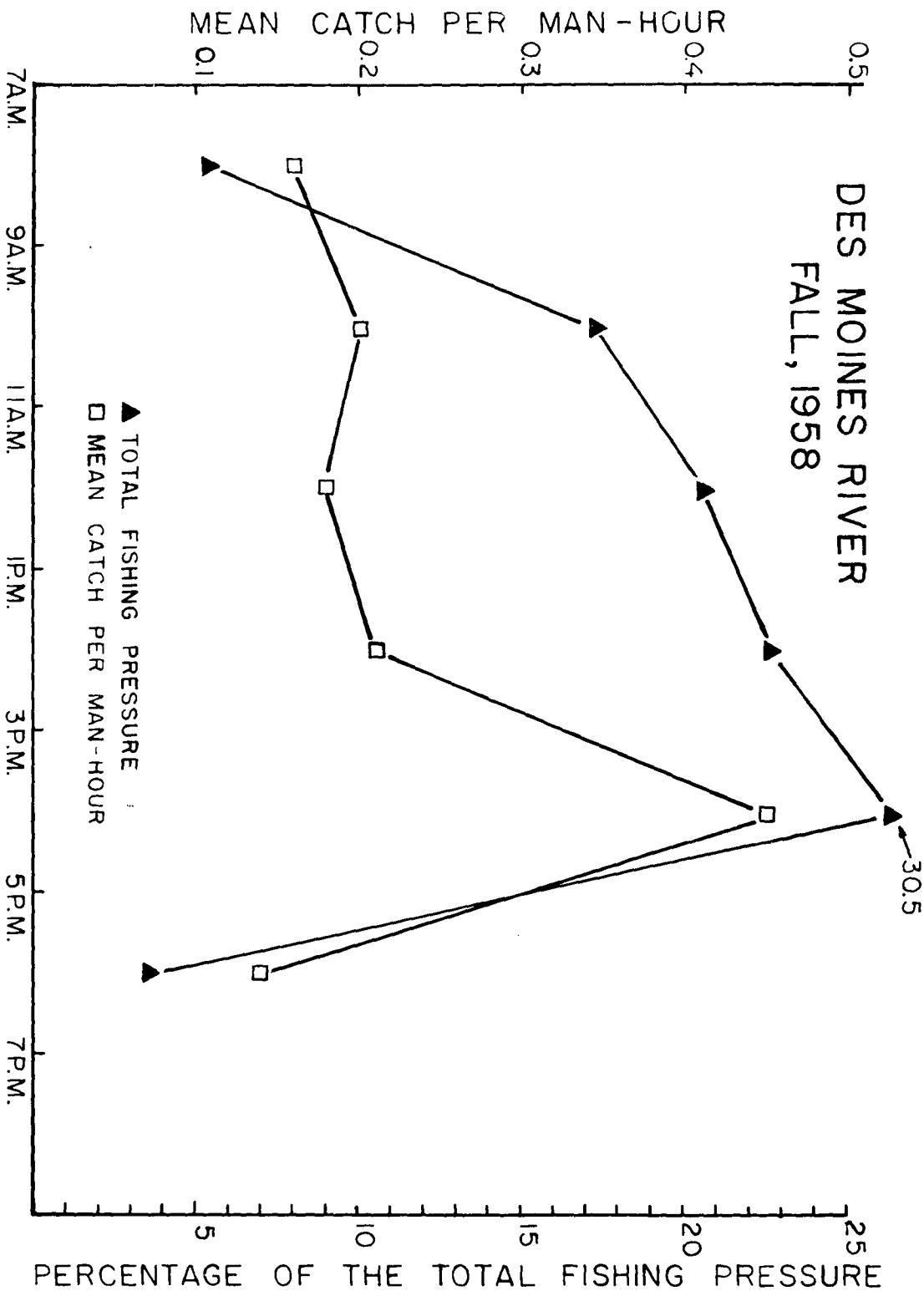

DES MOINES RIVER
SUMMER, 1958
MEAN CATCH PER MAN-HOUR
PERCENTAGE OF THE TOTAL FISHING PRESSURE
▲ TOTAL FISHING PRESSURE
□ MEAN CATCH PER MAN-HOUR
6A.M.
8A.M.
10A.M.
12P.M.
2P.M.
4P.M.
6P.M.
8P.M.
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
25
20
15
10
5

Figure 12. Fishing pressure and catch per man-hour at different times of the day in a 6.5-mile section of the Des Moines River, September 8 to November 16, 1958.


DES MOINES RIVER
FALL, 1958
MEAN CATCH PER MAN-HOUR
0.1
0.2
0.3
0.4
0.5
7A.M.
9A.M.
11A.M.
1P.M.
3P.M.
5P.M.
7P.M.
▲ TOTAL FISHING PRESSURE
□ MEAN CATCH PER MAN-HOUR
30.5
5
10
15
20
25
PERCENTAGE OF THE TOTAL FISHING PRESSURE

during the day even though fishing pressure was high. This may be due to the fact that late-evening fishermen usually are seeking channel catfish and many of them had just begun their fishing trip at the time of the interview. Usually, fishing success for channel catfish is better from sundown until approximately midnight. Also, in the summer of 1957, over 75 percent of all the fish caught by late-evening fishermen were carp but carp made up only 60 percent of all the fish caught by late-evening, spring anglers of 1958.

Fishermen seeking channel catfish in the summer of 1958 had poor success. Many of these anglers probably directed their efforts toward catching channel catfish during the early part of their fishing trip and then, if they caught no channel catfish, turned their efforts towards catching other species during the latter portion of the trip. A fishing trip conducted in such a manner probably would have resulted in a lower-than-average rate of catch in the 6 to 8 p.m. period because many channel catfishfishermen begin their fishing trip at this time. Figure 11 shows that the rate of catch in the 6 to 8 p.m. period was quite low.

Fishermen in the fall of 1958 experienced a poor rate of catch during all periods of the day except for the 3 to 5 p.m. period (Figure 12). Most of the fish creeled during the 3 to 5 p.m. period were carp, the only fish which maintained a suitable fishery for those who enjoyed catching

them.

In general, fishing pressure was greatest at that time of the day when the catch per man-hour was highest (Figures 8, 10, 11 and 12), but in the fall of 1957, the data do not show this relationship (Figure 9). One possible explanation for this phenomenon is that during the fall, many anglers were seeking game fish and primarily walleyes. Most walleyes were caught just below the dams at Fraser and Boone and just downstream from some of the riffle areas. Since the number of good walleye fishing areas was limited, the rate of catch probably should have dropped with increased fishing pressure unless, of course, the anglers shifted their efforts toward catching the more easily caught species.

It was pointed out earlier that the total amount of fishing pressure seemed to have little effect upon catch per man-hour in the summer of 1957 (Figure 5). That fishing success may have a bearing upon fishing pressure is suggested by the fact that fishing pressure was usually greater during the time of day when fishing success was greater, as just described. It is further suggested by the fact that fishing pressure was much lighter in 1958 than in 1957 (Table 19). In 1958, fishing pressure was 36.8 percent lighter in the summer and 43.6 percent lighter in the fall. Evidently the poor success of the 1958 anglers prompted them to make fewer trips to the river. However, neither 1957 nor

Table 19. Comparison between the mean catch per man-hour and the mean number of fisherman-hours expended per week for two years, 1957 and 1958, on a 6.5-mile section of the Des Moines River.

	Mean catch per man-hour		Mean no. hrs. per week	
Season	1957	1958	1957	1958
Spring	-	0.30	-	2,196.6
Summer	0.45	0.40	3,912.0	2,473.8
Fall	0.28	0.21	1,729.0	976.8
Totals	0.41	0.33		

1958 with mean catches of 0.41 and 0.33 fish per man-hour, respectively, could be considered good fishing years on the Des Moines River.

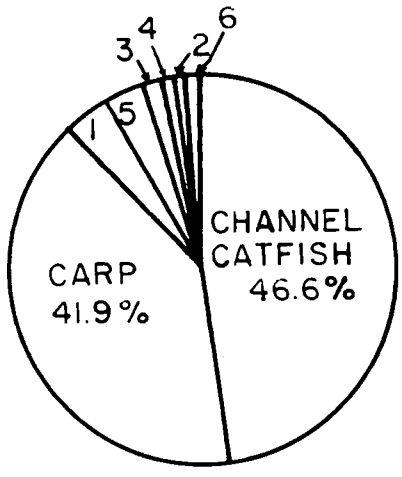
Species Composition

Boat anglers, shore anglers and waders differed considerably in their methods of fishing and, therefore, in the species composition of their catch (Tables 14, 15, 16, 17, and 18). Boat anglers and waders appeared to specialize in channel catfish although at times the emphasis was placed on walleyes. Some individual fishermen specialized in smallmouth bass or flathead catfish.

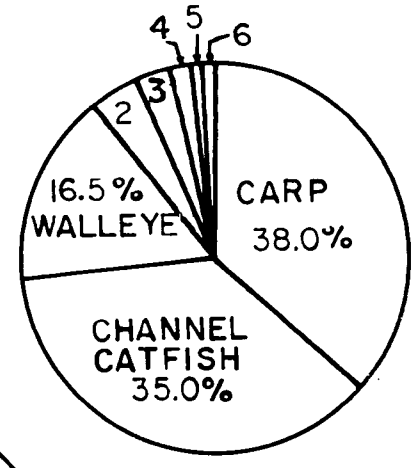
Since the boat fishermen, shore fishermen and waders were not always equally sampled in the interviewing, it was

necessary to adjust the data on the basis of the number of each type of fisherman counted to arrive at the best estimate of the species composition of the total harvest. It is evident from Figure 13 and Tables 14, 15, 16, 17, and 18 that the channel catfish and carp comprise virtually the entire catch of fish during most seasons. In the five seasons censused, the combined catch of channel catfish and carp made up between 73.0 percent and 88.5 percent of the total catch in numbers. Walleyes became important in the total catch in the fall only, although a considerable amount of fishing pressure was exerted toward catching walleyes during all seasons. From a recreational standpoint the importance of walleyes was much greater than their abundance in the catch indicated. In the late fall, walleyes were practically the only species sought. Suckers belonging to the genus Moxostoma primarily, comprised 16.5 percent of the total catch in the spring. During the summer of 1957 suckers made up a mere one percent of the total catch but were encountered more often in the following seasons. Since suckers are not sought or preferred by river anglers, the increase in suckers in the total catch either indicated a population increase of suckers or the unavailability of more desirable species. The latter explanation seems to be more plausible since the total catch of channel catfish dropped significantly in 1958. Many suckers were caught to use

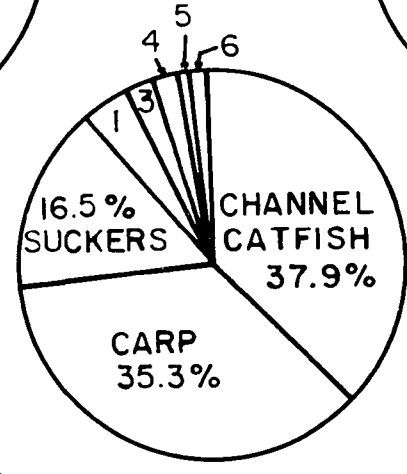
Figure 13. Percentage composition of the total harvest of fish during five seasons on a 6.5-mile section of the Des Moines River.



SUMMER 1957

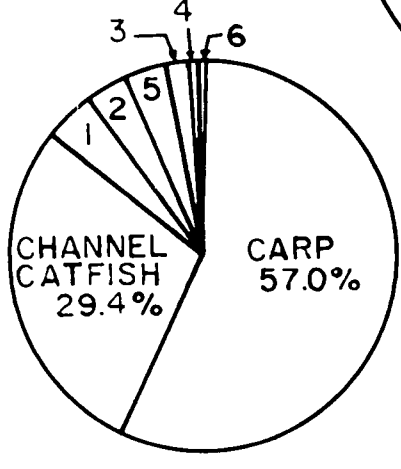


FALL 1957

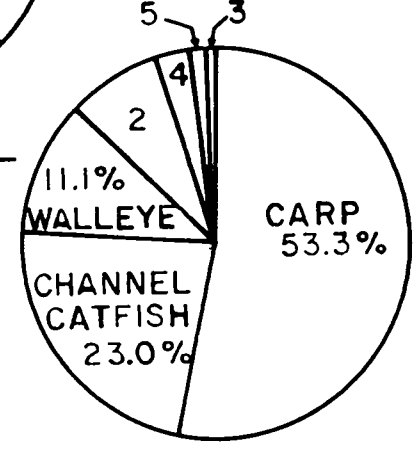


SPRING 1958

DES MOINES RIVER



SUMMER 1958



FALL 1958

LEGEND

1 WALLEYE
2 SUCKERS
3 SMALLMOUTH BASS
4 FLATHEAD CATFISH
5 BULLHEADS
6 OTHERS

their entrails and flesh as bait for channel catfish.

Another consequence of the unavailability of channel catfish was the rise in the relative importance of carp in the total catch. In the summer of 1958 carp made up well over 50 percent of all fish caught. Evidently anglers preferred to fish for something they could catch rather than spend long hours fishing for channel catfish or game fish which provided a poor rate of catch. When channel catfish were unavailable, the astute fishermen turned their attention toward fishing for carp.

The other species of fish in the fishery were never important to the total catch. Bullheads were captured in limited numbers during the summer seasons. Harrison (1956) reported a considerable harvest of bullheads in the Des Moines River but most of these bullheads were taken in the river from an impounded area near Humboldt, Iowa. Smallmouth bass are of minor importance even though in some areas of the Des Moines River the bass ranks second in abundance among the game and pan fish and is outnumbered only by the channel catfish (Harrison, 1954a). Evidently the smallmouth bass population in the study area was not large because few bass were captured with the electrical-shocking device which is known to be very efficient in collecting bass. Only 15 smallmouth bass were captured in many hours of shocking. Nevertheless, several nice catches of bass were recorded at

the two dams where shocking was never attempted. Only a few anglers ever tried to catch smallmouth bass and most anglers either were not aware of the smallmouth bass population or they were incapable of catching them because smallmouth bass made up only 1.7 percent of the total catch during the five seasons censused. Flathead catfish remained the favorite species of many anglers but the overall importance of the flathead catfish in the total catch amounted to only 1.3 percent. It requires much patience and special types of bait to hook flathead catfish.

Total Harvest

The total number of fish caught during each season was estimated by multiplying the total number of hours expended by the mean catch per man-hour (Tables 20, 21, 22, 23, and 24). To estimate the total weight of the catch the total number of fish was multiplied by the percentage of the total catch which each species comprised (see Tables 14, 15, 16, 17, and 18). The total lengths of the fish were recorded during the angler interviews and grouped into 2-inch total length groups (Appendix, Tables 43 through 49). Length-weight formulas were applied to each 2-inch group using the mean total length for each group. The estimated weights for each 2-inch group were determined and then summed to obtain an estimate of the total weight of the catch for each

Table 20. Species composition of estimated catch in numbers and pounds on a 6.5-mile section of the Des Moines River, July 7 to August 24, 1957.

Species	Total no. of fish	Total no. of pounds	Average wt. in pounds	Percentage of total no. of fish	Percentage of total wt. of fish	Pounds/ surface acre
Channel catfish	5,743	3,429.8	0.60	46.7	40.4	17.4
Carp	5,163	3,757.9	0.73	41.9	44.2	19.1
Walleye	456	415.2	0.91	3.7	4.9	2.1
Smallmouth bass	197	254.1	1.29	1.6	3.0	1.3
Flathead catfish	111	321.1	2.89	0.9	3.8	1.6
Bullheads	444	96.6	0.22	3.6	1.1	0.5
Suckers	111	126.5	1.14	0.9	1.5	0.6
Others	86	94.4	1.10	0.7	1.1	0.5
Totals	12,311	8,495.6	0.69			43.1

Table 21. Species composition of estimated catch in numbers and pounds on a 6.5-mile section of the Des Moines River, August 25 to November 12, 1957.

Species	Total no. of fish	Total no. of pounds	Average wt. in pounds	Percentage of total no. of fish	Percentage of total wt. of fish	Pounds/ surface acre
Channel catfish	2,003	748.9	0.37	36.2	15.8	3.8
Carp	2,004	2,155.0	1.04	37.3	45.6	10.9
Walleye	907	929.6	1.02	16.4	19.7	4.7
Smallmouth bass	155	184.5	1.19	2.8	3.9	0.9
Flathead catfish	111	287.3	2.59	2.0	6.1	1.5
Bullheads	44	24.6	0.56	0.8	0.5	0.1
Suckers	205	367.6	1.79	3.7	7.8	1.9
Others	44	29.9	0.68	0.8	0.6	0.2
Totals	5,533	4,727.4	0.85			24.0

Table 22. Species composition of estimated catch in numbers and pounds on a 6.5-mile section of the Des Moines River, March 22 to June 15, 1958.

Species	Total no. of fish	Total no. of pounds	Average wt. in pounds	Percentage of total no. of fish	Percentage of total wt. of fish	Pounds/ surface acre
Channel catfish	3,142	2,402.7	0.76	37.9	28.0	12.2
Carp	2,935	3,473.9	1.18	35.4	40.5	17.6
Walleye	307	325.4	1.06	3.7	3.8	1.7
Smallmouth bass	199	258.3	1.30	2.4	3.0	1.3
Flathead catfish	191	624.0	3.27	2.3	7.3	3.2
Bullheads	66	30.1	0.46	0.8	0.4	0.2
Suckers	1,360	1,229.4	0.90	16.4	14.4	6.2
Others	91	225.3	2.48	1.1	2.6	1.1
Totals	8,291	8,569.1	1.03			43.5

Table 23. Species composition of estimated catch in numbers and pounds on a 6.5-mile section of the Des Moines River, June 16 to September 7, 1958.

Species	Total no. of fish	Total no. of pounds	Average wt. in pounds	Percentage of total no. of fish	Percentage of total wt. of fish	Pounds/ surface acre
Channel catfish	3,621	2,237.7	0.62	29.9	20.3	13.6
Carp	6,807	7,465.1	1.09	56.7	67.9	34.9
Walleye	460	400.0	0.88	3.8	3.6	2.3
Smallmouth bass	157	149.5	0.95	1.3	1.4	0.8
Flathead catfish	109	283.5	2.60	0.9	2.6	0.5
Bullheads	400	80.7	0.20	3.3	0.7	2.0
Suckers	448	364.0	0.81	3.7	3.3	2.3
Others	48	19.5	0.41	0.4	0.2	0.2
Totals	12,110	11,000.0	0.91			56.6

Table 24. Species composition of estimated catch in numbers and pounds on a 6.5-mile section of the Des Moines River, September 8 to November 16, 1958.

Species	Total no. of fish	Total no. of pounds	Average wt. in pounds	Percentage of total no. of fish	Percentage of total wt. of fish	Pounds/ surface acre
Channel catfish	486	202.8	0.42	23.0	10.3	1.1
Carp	1,125	1,167.9	1.04	53.2	59.4	6.5
Walleye	235	330.8	1.41	11.1	16.8	1.8
Smallmouth bass	17	23.4	1.38	0.8	1.2	0.1
Flathead catfish	51	75.7	1.48	2.4	3.9	0.4
Bullheads	34	8.5	0.25	1.6	0.4	0.1
Suckers	150	83.6	0.56	7.1	4.3	0.5
Others	17	73.3	4.31	0.8	3.7	0.4
Totals	2,115	1,966.0	0.93			11.0

species. Length-weight data were available for the following species collected in the same section of the Des Moines River: carp (Rehder, 1959); channel and flathead catfish (Muncy, 1957); and walleyes (Schmulbach, in press). For the other species data were taken from Carlander (1953).

From the standpoint of total weight, carp were the most important species creeled during all seasons and comprised between 40.5 and 67.9 percent of the total weight of the catch. Except for the summer of 1957, the average carp weighed slightly over one pound. Channel catfish, although numerically the most important species caught in the summer of 1957 and the spring of 1958, were second in importance to the total weight of the catch during these seasons and in the summer of 1958. Walleyes were second in importance to the total weight of the catch during the two fall seasons.

Suckers comprised over 14 percent of the total weight of the catch in the spring but this was the only season in which they were important. Flathead catfish, a favorite with some fishermen because of their large size, averaged over two and one-half pounds during all seasons except the fall of 1958 when they averaged approximately one and one-half pounds. Flathead catfish were never important to the catch in either total numbers or total weight.

The average weight for all fish combined displayed a gradual increase during the year starting at a low point in

the summer and culminating at a high point in the spring. The average weight of all fish in the spring was 1.03 pounds. The higher average weight of the spring fish probably was due to increased vulnerability of the larger fish of each species and few young fish were recruited into the fishery during the spring.

In 1958, the only year which was censused completely, the summer season provided 53.8 percent of the total harvest while the spring and fall comprised 36.8 and 9.4 percent of the harvest (Table 25). It was estimated that approximately 119.4 pounds of fish per acre which is equivalent to 3,312 pounds of fish per mile were harvested in 1958, a rather poor fishing year. However, 51.8 percent of the total harvest by weight consisted of carp.

The total weight of the angler's harvest in the Des Moines River must be considered as being high. Carlander (1953) lists only a few annual yield per acre estimates from warm-water streams and the annual yield estimates from the Des Moines River exceed even those from the southern part of the United States. However, Clark et al. (1952) reported an annual harvest of 253 pounds per acre or 1,617 pounds per mile on Riley Creek in Ohio. Medicine Creek in Nebraska produced 11,428.6 pounds of fish per mile but this was an atypical situation since the creek actually formed the tailwaters of a reservoir and many of the fish caught were

Table 25. Total estimated harvest of fish in numbers and pounds during five seasons on a 6.5-mile section of the Des Moines River.

Season	Length of season (days)	Total catch		Yield per acre per season		Yield per mile per week		Percentage of total catch/year
		No.	Lbs.	No.	Lbs.	No.	Lbs.	
Summer-1957	49	12,311	8,496	62.5	43.1	271	186.7	33.7[a]
Fall-1957	80	5,533	4,727	28.1	24.0	74	63.6	18.7[a]
Spring-1958	86	8,291	8,569	46.3	47.9	104	107.3	36.8
Summer-1958	85	12,111	11,000	67.7	61.5	153	139.4	53.8
Fall-1958	70	2,115	1,960	10.7	10.0	33	30.2	9.4

Estimated annual yield for 1958 = 119.4 pounds per acre or
3,312.0 pounds per mile

[a]Estimated percentages since the spring and early summer of 1957 were not censused.

actually produced in the reservoir (Nicholson and Borges, 1955). Elser (1954) reported a high harvest of fish, 780 pounds per mile, on the Potomac River in Maryland, a large, heavily-fished river. Two Missouri smallmouth streams, the Niangua and the Big Piney Rivers, averaged 13.9 pounds and 16.7 pounds of fish per acre per year (Fleener, 1952). Another Missouri stream, Clearwater River, averaged between 6.8 and 15.2 pounds per acre per year between the years 1949 to 1952 (Kathrein, 1953). Trout streams, such as the Brule River in Wisconsin (O'Donnell, 1945) and the Split Rock River in Minnesota (Hale, 1952) averaged 9.5 pounds and 60 pounds per acre per year respectively.

Characteristics of the Fishermen

As a supplementary part of the creel census, data were collected on certain characteristics of the fishermen which may be of significance in considering any management plan or explaining some of the seasonal shifts in fishing pressure and harvest.

Distance traveled to fish

It was evident from the onset of the study that many of the fishermen on the study area came from surrounding towns and farms. In the interviews, all fishermen were asked their place of residence. Over 70 percent of all anglers lived within a 10-mile radius of the station at which they

were contacted and over 87 percent lived within a 20-mile radius (Table 26). Approximately 2.2 percent lived farther than 75 miles from the river or were from some other state, and in most cases these anglers were visiting relatives in the immediate vicinity. The Des Moines River fishery must be classified as an extremely "local fishery". Greenbank (1957) analyzed the distance traveled by winter anglers on the upper Mississippi River and found that 63 percent of all anglers traveled less than 10 miles in order to fish and 80 percent traveled less than 20 miles. However, no attempt was made to analyze the place of residence of the summer anglers which probably would have been less "local" in nature.

It was thought that the two lowhead dams on the study area might have attracted anglers from distant towns. However, the extremely local nature of the fishery indicated that the lowhead dams merely concentrated the local fishermen and did not attract appreciable numbers of anglers from distant towns and farms.

Species of fish sought

Although fishermen were not asked what species of fish they were seeking, the type of bait used is somewhat specific for certain species. Tables 27, 28, 29, 30, and 31 are a partially subjective approach to the problem of what species was the most sought in the river. Several of the

Table 26. Percentage of the fishermen contacted on a 6.5-mile section of the Des Moines River who lived within a specified distance from the point of the contact. All percentages are expressed as percent of the total number of anglers.

Season	0-5 mile rad.	5-10 mile rad.	10-15 mile rad.	15-20 mile rad.	20-30 mile rad.	30-40 mile rad.	40-50 mile rad.	50-75 mile rad.	Over 75 mile rad.	Out-of state
Summer-1957	38.6	31.8	0.2	14.0	4.0	3.2	2.8	0.6	2.1	1.1
Fall-1957	40.0	32.9	0.7	11.9	6.1	2.7	2.9	0.2	2.2	0.4
Spring-1958	37.1	32.2	1.3	18.2	3.9	3.6	2.7	-	1.0	-
Summer-1958	37.7	36.3	0.8	13.9	3.5	2.8	2.2	0.5	1.7	0.6
Fall-1958	39.5	25.9	0.4	20.7	7.1	2.6	1.9	1.9	-	-
Mean	38.6	32.8	0.6	15.2	4.4	3.1	2.6	0.5	1.6	0.6

Table 27. Species of fish sought by anglers (as determined by the bait used) and catch per man-hour on a 6.5-mile section of the Des Moines River, July 7 to August 24, 1957.

Species sought	Percentage of all anglers	Total no. hrs. fished	Total no. fish caught	Catch per man-hour
Channel catfish	28.9	765.0	368	0.48
Game fish (especially channel catfish)	3.5	159.25	41	0.26
Game fish (general)	16.8	527.50	104	0.20
Flathead catfish	1.3	89.25	5	0.06
Carp	9.2	270.5	330	1.22
General	40.4	1,037.00	438	0.42
Total		2,848.5	1,286	0.45

Table 28. Species of fish sought by anglers (as determined by the bait used) and catch per man-hour on a 6.5-mile section of the Des Moines River, August 25 to November 12, 1957.

Species sought	Percentage of all anglers	Total no. hrs. fished	Total no. fish caught	Catch per man-hour
Channel catfish	13.3	63.25	9	0.14
Game fish (especially channel catfish)	2.4	31.25	2	0.06
Game fish (general)	27.1	235.0	34	0.14
Flathead catfish	0.8	10.00	0	0.0
Carp	10.5	59.00	47	0.80
General	45.9	466.75	146	0.31
Total		865.25	238	0.28

Table 29. Species of fish sought by anglers (as determined by the bait used) and catch per man-hour on a 6.5-mile section of the Des Moines River, March 22 to June 15, 1958.

Species sought	Percentage of all anglers	Total no. hrs. fished	Total no. fish caught	Catch per man-hour
Channel catfish	6.6	68.5	18	0.26
Game fish (especially channel catfish)	3.5	77.75	36	0.46
Game fish (general)	6.0	105.5	24	0.23
Flathead catfish	3.2	69.25	5	0.07
Carp	7.9	115.75	81	0.70
General	72.8	918.00	248	0.27
Total		1,354.75	412	0.30

Table 30. Species of fish sought by anglers (as determined by the bait used) and catch per man-hour on a 6.5-mile section of the Des Moines River, June 16 to September 7, 1958.

Species sought	Percentage of all anglers	Total no. hrs. fished	Total no. fish caught	Catch per man-hour
Channel catfish	14.6	197.25	70	0.35
Game fish (especially channel catfish)	6.9	175.25	44	0.25
Game fish (general)	11.9	191.25	43	0.23
Flathead catfish	1.5	26.25	0	0.0
Carp	11.0	180.00	214	1.19
General	54.1	961.25	315	0.33
Total		1,731.25	686	0.40

Table 31. Species of fish sought by anglers (as determined by the bait used) and catch per man-hour on a 6.5-mile section of the Des Moines River, September 8 to November 16, 1958.

Species sought	Percentage of all anglers	Total no. hrs. fished	Total no. fish caught	Catch per man-hour
Channel catfish	3.4	10.5	4	0.38
Game fish (especially channel catfish)	4.9	16.5	2	0.12
Game fish (general)	27.9	186.25	17	0.09
Carp	13.1	70.50	50	0.71
General	50.7	325.00	52	0.16
Total		608.75	125	0.21

categories used are defined as follows:

Channel catfish A category referring to those fishermen who used baits such as river mussels, liver, etc. which were specifically intended to catch channel catfish.

Game fish (especially channel catfish) A category referring to those fishermen who fished at some time during their trip both with live bait such as minnows and with a specific catfish bait such as river mussels or chicken entrails. These fishermen had a chance to catch walleyes, smallmouth bass, and other game fish but were primarily seeking channel catfish.

Game fish (general) Refers to fishermen who were using live bait (i.e., minnows, crayfish) or artificial lures for bait and had a chance to catch almost any type of game fish including walleyes, smallmouth bass, crappies, channel catfish, and even small flathead catfish.

Carp Refers to fishermen who used doughballs, corn, or bread as bait and were specifically seeking carp.

General Refers to fishermen who used many types of baits which afforded the anglers an opportunity to catch all species of fish.

During every season at least 40 percent of all anglers evidently were not particular about which species they caught. Of course, many of these anglers initially were seeking channel catfish or game fish but after being unsuccessful for a period of time, they used baits which enabled them to catch the more easily captured species such as carp. This "general" category was especially high in the spring, 72.8 percent of all anglers, which probably reflects the poor fishing success of the spring anglers (Table 29). Fishermen preferred to catch some fish rather than be too selective and go home with no fish at all. Since the seasons on walleyes and smallmouth bass did not open until one-half of the spring season was over, the percentage of anglers seeking game fish was only 6.0 percent. Also, anglers who sought only channel catfish were not encountered as

often in spring as in other seasons. Evidently many anglers who ordinarily fished only for channel catfish also fished for and caught carp and suckers. Possibly many of these carp and suckers were subsequently used as bait for catfish.

During the fall seasons, anglers seeking game fish (primarily walleyes) comprised over 25 percent of the fishing population. These anglers made up an important segment of the fall fishermen despite a rate of catch below 0.15 fish per man-hour.

Carp fishermen consistently comprised approximately 10 percent of all the fishermen but their rate of catch was usually more than twice as great as any other group. In the fall of 1958 (Table 31) the percentage of carp fishermen rose to its highest point, 13.1 percent of all fishermen. Even some of the more avid fishermen who usually sought game fish, turned to carp for action because the rate of catch for game fish was very low.

The percentage of fishermen seeking only flathead catfish was always low and their rate of catch was also very poor. Fishermen, seeking flathead catfish, expect a poor rate of catch, however, and are usually satisfied with one or two "strikes" each trip.

Even though the channel catfish was one of the most important species creeled during all seasons, the percentage of fishermen seeking only channel catfish was high only in

the summer of 1957 (28.9 percent). The poor success of channel catfishfishermen in 1958 was reflected in the small percentage of all fishermen who sought this species in the spring and summer seasons, 6.6 and 14.6 percent respectively.

Sex of anglers

Men constituted 72.7 percent of all anglers encountered during the course of the study (Table 32). Women averaged 14.9 percent, boys 10.4 percent, and girls 2.0 percent of the total number of anglers contacted. All males or females too young to buy licenses were designated as boys or girls (Iowa requires all residents over 16 years of age to purchase a license). All elderly-looking men were asked whether they were retired and approximately 8.5 percent of all the men answered affirmatively to this question. However, this figure should be considered a minimum estimate since some men who were retired may not have looked old enough in the eyes of the census taker to be asked about retirement. The percentage of retired males who fished each season remained constant and the primary reason for the small amount of seasonal variation was due primarily to fluctuations in the numbers of men who were not retired. Also, the number of women who fished each season was reasonably constant and fluctuations in the seasonal percentage composition were attributed largely to higher or lower percentages of men and boys who fished. The drop in the number of boys who fished

Table 32. Sex of anglers including the number of retired men on a 6.5-mile section of the Des Moines River. All numbers are expressed as percentages of all fishermen interviewed except numbers of retired men which are expressed as percentages of all men.

Season	Men		Women	Boys (under 16)	Girls
	Total	Retired			
Summer-1957	71.9	8.5	14.3	11.8	2.0
Fall-1957	74.6	10.7	17.3	6.8	1.2
Spring-1958	75.0	6.7	11.4	12.0	1.6
Summer-1958	70.9	7.9	14.6	12.1	2.4
Fall-1958	70.6	11.2	22.3	4.5	2.6
Mean	72.7	8.5	14.9	10.4	2.0

during the fall was caused by the resumption of school work at approximately the first week in September.

The percentage of male and female fishermen interviewed on the Des Moines River was almost identical to that reported on South Dakota waters (Clothier and Boussu, 1954. Elser (1954) reported that men comprised 82 percent, women 12 percent, and children under 14 years of age 6 percent of all anglers on the Potomac River. The fishing population on the Madison River in Montana (U. S. Fish and Wildl. Serv.,

1954) consisted of 83 percent men, 12 percent women, and 5 percent children under 16 years of age. The higher incidence of women and children in the Des Moines River fishery probably was due to the easy access which anglers have to the river. At many places cars were driven to the banks of the river and on one occasion anglers were observed fishing while in their cars.

Since there was a fairly large number of female anglers, it was of interest to compare their catch per hour with that for men. All interviews were recorded on a fishing party basis and, therefore, only fishing parties composed of one sex could be used for analysis (Table 33). Most women accompany their husbands when fishing and, therefore, the sample of strictly female fishing parties was not large. A chi-square test was computed to test whether a significant difference existed between the rate of catch for men and women. The resulting chi-square value, 46.85, was highly significant at the 95 percent probability level. This indicates that men were more successful fishermen than women. Other studies, notably those of Greenbank (1957) and Klein (1954), also indicated that men definitely were better fishermen than women. On the other hand Eschmeyer (1936) noted that proportionately fewer women than men took no fish on Fife Lake, Michigan.

Table 33. Comparison between the catch per man-hour of fishing parties consisting only of men and fishing parties consisting only of women during five seasons on a 6.5-mile section of the Des Moines River.

Season	Male fishing parties only				Female fishing parties only			
	No. fishermen	No. hours fished	No. fish caught	Catch per man-hour	No. fishermen	No. hours fished	No. fish caught	Catch per man-hour
Summer-1957	607	1,552.25	801	0.52	27	78.75	25	0.32
Fall-1957	248	499.75	136	0.27	31	79.5	41	0.52
Spring-1958	375	865.5	238	0.33	11	12.75	9	0.71
Summer-1958	382	836.0	437	0.52	28	57.5	9	0.16
Fall-1958	142	322.0	43	0.13	15	36.75	3	0.08
Totals	1,754	4,085.5	1,655	0.41	112	265.25	87	0.33

$x^2 = 46.85$ d.f. = 4 $x^2_{05} = 9.49$

Preferred gear

Fishing conditions on the Des Moines River render certain types of fishing gear relatively ineffectual. For instance, practically all fishing is done with natural baits and because of the current heavy weights are required to sink these baits to the bottom. Frequent entanglement on brushpiles and rocks require the use of stiff rods and strong lines to free the bait from these snags. Therefore, light rods and lines were used by few anglers (Table 34). The category "river rods," as used in the table, refers to heavy surf or trolling rods which are fitted with bait-casting reels. Many of these reels are equipped with heavy

Table 34. Type of fishing rods used by anglers, expressed as a percentage of the total number of fishing rods, during five seasons on a 6.5-mile section of the Des Moines River.

Season	Casting rods	River rods	Spinning rods	Fly rods	Cane poles and hand lines
Summer-1957	72.6	10.7	7.4	5.0	4.3
Fall-1957	70.1	11.1	8.8	5.8	4.2
Spring-1958	68.3	15.8	12.0	3.7	0.2
Summer-1958	63.7	17.1	10.3	5.8	3.1
Fall-1958	66.2	13.0	10.8	7.3	2.7
Mean	68.7	13.5	9.5	5.2	3.1

line of more than 20-pound test. River rods were popular with flathead fishermen but casting rods were overwhelmingly the most popular type of rod and comprised 68.7 percent of all rods. River rods made up 13.5 percent, spinning rods 9.5 percent, flyrods 5.2 percent and cane poles and hand lines 3.1 percent of all rods. Spinning rods and flyrods were used extensively by waders. The old standby, the cane pole, was used primarily by boys and girls.

Since Iowa law permits the use of two lines, Table 35 was compiled to test whether the use of two lines actually resulted in a higher catch per man-hour. The manner in which the data were collected precluded the precise delimitation of anglers who used only one line from anglers who used two lines. However, if fishing parties who averaged more than one line per person are compared with those who used only one line per person, a crude estimate of the relative efficiency of fishermen using one and two lines can be formulated. Except for the summer of 1958 when fishermen relied heavily upon carp to fill their creel, there was no significant difference between the rate of success of fishermen using one or two lines. The difference in the catch per hour noted in the summer of 1958 probably can be attributed to the poor catch of channel catfish during that season. Many fishermen seeking catfish and game fish are boat anglers and waders who use only one line while carp

fishermen fish primarily from the shore and often use two lines.

Table 35. Catch per man-hour of angler parties using one line per person compared with the catch per man-hour of angler parties using more than one line per person on a 6.5-mile section of the Des Moines River.

	Summer 1957	Fall 1957	Spring 1958	Summer 1958	Fall 1958
	Fishing parties with one line per fisherman				
No. lines	823	248	382	455	134
No. hrs. fished	1,900.75	454.0	812.5	898.5	259.0
No. fish caught	884	124	258	282	50
Catch per man-hour	0.46	0.27	0.32	0.31	0.19
	Fishing parties with more than one line per fisherman				
No. fishermen	340	163	246	325	129
No. lines	592	284	417	545	236
No. hrs. fished	947.75	411.25	452.25	834.75	349.75
No. fish caught	389	114	154	404	75
Catch per man-hour	0.41	0.28	0.28	0.48	0.21
Catch per pole-hour	0.24	0.16	0.17	0.29	0.12

Preferred baits

Minnows, including large creek chubs, were the most popular bait, being used by 21.3 percent of all anglers (Table 36). Worms, which were used by 20.7 percent of all anglers, were second in overall popularity. Following the two most popular baits and listed in the order of their preference by anglers were doughballs, shrimp, commercial catfish bait, liver, artificial lures, river mussels, chicken entrails, and crayfish. Other baits which were frequently encountered were chicken blood, fish entrails, fish flesh (cut bait), and sweet corn. Some rather unusual baits such as lobster tail, beefsteak, and sardines were offered as tempting baits for channel catfish.

Seasonal changes in the bait used were dependent upon the species of fish sought and the availability of the bait. For instance, in the fall more anglers sought game fish than during any other season and consequently proportionately more minnows were used as bait. Worms were used extensively during all seasons but they were more available in the spring as was shown in 1958 when they constituted 38.1 percent of all baits used. River mussels are an exclusive bait for channel catfish, and were used primarily during the summer. River mussels were used sparingly during the fall because channel catfish were not eagerly sought in this season and during the spring because high water levels and cool

Table 36. Frequency of occurrence of preferred baits, expressed as a percentage of all baits, used by anglers during five seasons on a 6.5-mile section of the Des Moines River.

Baits used	Summer 1957	Fall 1957	Spring 1958	Summer 1958	Fall 1958	Total
Minnows	21.3	22.9	18.0	18.9	32.1	21.3
Worms	14.4	21.2	38.1	18.6	15.0	20.7
Doughballs	16.2	19.1	16.8	19.1	19.0	17.6
Shrimp	15.0	10.0	6.4	9.2	8.0	10.7
River mussels	3.1	0.7	0.5	4.4	1.8	2.5
Artificial lures	1.5	6.0	1.6	2.3	4.8	2.6
Catfish bait (commercial)	13.2	8.8	8.1	11.6	6.2	10.7
Chicken entrails	3.2	1.0	0.7	3.2	2.2	2.4
Liver	3.5	4.3	2.2	5.1	3.6	3.8
Crayfish	2.2	1.2	-	1.7	0.7	1.4
Others	6.4	4.8	7.9[a]	5.9	6.6	6.3

[a]Cut bait made up 4.2%.

water temperatures discouraged their collection. The use of crayfish followed the same general pattern as did river mussels. Artificial lures were used primarily by walleye fishermen during the fall seasons. The most popular lures were lead-headed jigs and spoons. Doughballs were used exclusively by carp fishermen. Since the number of carp fishermen was constant from season to season, the percentage of doughballs used each season was also fairly constant.

The subject of the most successful bait has been debated since anglers first gathered to talk of their angling success. The answer to this question is a difficult one which becomes involved if one considers the many factors which could influence the success of a certain bait. The type of bait used depends largely upon the species of fish sought, the availability of the bait, the season of the year, the preference of the fisherman and, in some cases, the price of the bait. Perhaps the most important factor which influences the success of a bait, but also the most difficult to measure, is the individual skill or "know-how" of the angler. It has been shown repeatedly that a high percentage of the total catch is taken by a small percentage of the total number of anglers (Bennett and Durham, 1951; Elser, 1954; Lagler and DeRoth, 1953; Starrett and McNeil, 1952). However, since it is virtually impossible to evaluate accurately all the factors which affect the rate of

catch, any analysis of the most successful bait must be considered as nothing more than an "educated guess" which is dependent upon many variables.

In Table 37 an effort was made to objectively determine the most popular and most successful types of baits used on the Des Moines River. Fishermen seeking channel catfish use a wide variety of baits, some of which are very odoriferous. The baits were divided into two main categories, a single-bait category in which only a single type of bait was used during the course of the fishing trip, and a multiple-bait category in which more than one type of bait was used. The multiple-bait category was subdivided into fishing trips during which only channel catfish baits were used, i.e., shrimp, catfish baits, etc., and other fishing trips during which many baits were used that would catch almost any species of fish. This latter category was called "many bait types".

The most successful bait and practically the only one used to capture carp exclusively was the doughball. Only 35.6 percent of all parties fishing with doughballs were unsuccessful and the average rate of catch was 1.06 fish per man-hour. Many carp as well as other species were also taken on worms. Worms provided a mean catch per man-hour of 0.39 fish and fish captured on worms averaged 9.4 inches in total length. Over 60 percent of the fishermen using

Table 37. Number of unsuccessful fishing parties, catch per man-hour, and the mean total length of all fish caught on various baits on a 6.5-mile section of the des Moines River.

Baits used	Number of parties interviewed[a]	Unsuccessful fishing parties (%)	No. hours fished	No. fish caught	Catch per man-hour	Mean total length of fish (in.)
			Single baits			
Minnows	311 (482)	67.2	1,329.75	250	0.19	12.7
Worms	173 (294)	61.3	492.50	194	0.39	9.4
Doughballs	160 (272)	35.6	602.75	637	1.06	11.0
Shrimp	56 (82)	62.5	132.00	60	0.45	10.6
Artificial lures	42 (57)	59.5	112.75	37	0.33	15.9
Catfish bait (commercial)	53 (99)	67.9	157.00	75	0.48	9.4
Chicken entrails	11 (16)	27.3	42.75	23	0.54	13.1
River mussels	20 (30)	60.0	87.25	24	0.28	12.6
Liver	13 (20)	53.8	36.25	37	1.02	10.9
Others	28 (36)	71.4	76.50	27	0.35	12.7

[a]Number of fishermen in parentheses.

Table 37 (continued).

Baits used	Number of parties interviewed[a]	Unsuccessful fishing parties (%)	No. hours fished	No. fish caught	Catch per man-hour	Mean total length of fish (in.)
			Multiple baits			
Channel catfish baits	217 (384)	67.3	955.00	254	0.27	11.5
Many bait types	732 (1.482)	54.2	3,384.75	1,129	0.33	11.2

only worms as bait were unsuccessful.

Of the baits which were exclusively channel catfish baits, chicken entrails were the most successful. A mere 27.3 percent of all fishermen who used this bait exclusively were unsuccessful. The average rate of catch was 0.54 fish per man-hour and the mean total length of all fish was 13.1 inches. Liver was another successful catfish bait with a mean catch per man-hour of 1.02 fish but the average size of fish caught on liver was only 10.9 inches. Approximately 53.8 percent of all fishing parties using liver were unsuccessful. Shrimp and prepared catfish bait were fairly successful from the standpoint of mean catch per man-hour but most of their catch consisted of small channel catfish known as "fiddlers".

Artificial lures, though used sparingly, were moderately successful. The mean catch per man-hour was 0.33 fish and the average total length of all fish caught on artificial lures was 15.9 inches. Walleyes and smallmouth bass were the only species caught on artificial lures. Perhaps one reason for the higher-than-expected rate of catch for fishermen using artificial lures was the individual skill of the angler. Most of the fishermen who used artificial lures made frequent trips to the river and on that basis could be considered skilled anglers.

Minnows were very popular as bait but the rate of catch

per man-hour on minnows was low, 0.19 fish. Approximately two-thirds of all anglers using minnows as bait were unsuccessful.

The multiple bait users displayed below normal success insofar as catch per man-hour was conserned but the mean total length of the fish caught and the number of unsuccessful fishing parties was about average for all bait types. The reason for the poorer success of the multiple bait users probably can be correlated with the individual skill of the anglers. Family groups were often included under the multiple bait category and in many cases these fishermen were not skilled anglers.

On the Des Moines River the most successful catfish anglers were men who fished from boats early in the morning using chicken entrails, liver, shrimp or river mussels for bait. The most successful carp anglers were boat anglers who fished during the mid-afternoon or early evening with doughballs as bait. In a previous study Harrison (1957a) reviewed the effectiveness of different baits in catching carp and channel catfish in the Des Moines River. He concluded that blood, minnows, cheese bait, chicken entrails and frogs were very successful channel catfish baits from the standpoint of catch per man-hour. Corn, bread, and worms caught carp at a more rapid rate than did doughballs but none of these baits were used extensively.

NIGHT ANGLING

Any investigator who attempts to evaluate the magnitude of night fishing pressure is confronted with problems which are different from a daytime census. Obviously it is difficult to count the number of fishermen unless, of course, the number of access points is limited and enumeration can be accomplished as fishermen enter or leave the area. On a river with many access points this is impossible without the help of many census takers. Secondly, even after one knows that fishermen are present at a station it is often difficult to locate these anglers.

In an effort to obtain at least some measure of the night angling pressure, occasional trips were made to the river during 1957 and 1958 but no censusing schedule was established. Initially the investigator drove around the area with an auto visiting all access points. If anglers were sighted, they were counted and interviewed in the same manner as in the daytime census. If only the angler's car was sighted, the car was recorded as being present. The average number of anglers per car was computed from interviewing those fishermen who were found. By multiplying the average number of anglers per car by the number of cars a crude estimate was made of the number of anglers present who could not be counted.

A pre-addressed postal card was left on the windshield

of the car in an effort to obtain some voluntary information. All fishing parties who received the voluntary postal cards were asked the following questions: (1) the number of fishermen in the party; (2) method of fishing (i.e., boat, shore, or wading); (3) time fished; (4) number of lines; (5) type of tackle; (6) bait; (7) fisherman's home town; and (8) the number, size, and species of fish caught. Angler response to the voluntary creel census cards was poor in 1957 and only 8 out of 47 cards were returned to the Cooperative Fisheries Unit. The voluntary postal card technique was abandoned as the results were considered too meager to be of value. It was felt that the two primary reasons for the refusal of anglers to respond to the voluntary cards were: (1) the card was too complicated and most anglers refused to take the time to fill out all the blanks and, (2) not enough anglers were familiar with the work of the research unit and may, in fact, have been suspicious of the census taker.

However, after five seasons of creel-census work were completed the census taker knew a high percentage of the avid fishermen and it was decided to attempt another night census during the spring of 1959. The voluntary postal cards were simplified and only four questions were asked: (1) number of fishermen in the party; (2) number of hours fished; (3) fisherman's home town; and (4) number and type

of fish caught. Special emphasis was placed on the fact that this was a voluntary report and no signature was necessary.

The spring night schedule included 26 sampling dates and extended from May 7 to July 5. It was felt that 3 two-hour periods (8 to 10 p.m., 10 to 12 p.m., and 4 to 6 a.m.) were sufficient to adequately census the night pressure. Response to the voluntary creel-census cards was encouraging (3 out of 5 cards were returned) but unfortunately the weather was not cooperative. Heavy rains, cool temperatures and flooding conditions resulted in no fishing data from ten dates some of which were omitted entirely and on six other occasions only one or two parties were sighted.

Since relatively few night censuses were conducted, no accurate estimate of the total night angling pressure was possible. However, a crude estimate may be constructed from the meager amount of data available in 1957 and 1958. It is reasonable to assume that most of the night angling occurs between May 15 to September 1, a period of 107 days. Almost all night anglers are seeking either channel or flathead catfish. Most of those seeking channel catfish angle from dusk to midnight while fishermen seeking flathead catfish often fish all night.

The average amount of fishing pressure exerted by strictly night anglers was estimated from six census dates

in 1958. The average number of fishermen per night was multiplied by the length of the average night fishing trip (3.6 hours) to give an estimate of the mean number of hours expended each night by strictly night anglers, 52.9 man-hours.

In addition to the fishing pressure after dark, there were two periods of the day which were not accounted for in either the daytime or the night estimates. The daylight fishing day in spring and summer was considered to be 14 hours long but, in summer there are actually more than 14 hours of daylight. Therefore, all evening fishing pressure between 8 and 9 p.m. and all early-morning pressure between dawn and 6 a.m. was considered with the night fishing pressure. All the late-evening and early-morning census cards from daylight interviews were analyzed to ascertain how long the fishermen intended to fish after 8 p.m. or had fished before 6 a.m. The average number of hours fished each evening anglers who did not intend to fish after dark amounted to 8.7 fisherman-hours. This estimate was made directly from the analysis of the late-evening census cards. Darkness was considered to occur at 9 p.m.

Early-morning angling pressure was similarly computed from the early-morning census cards and the average number of fisherman-hours expended each "night" by early-morning anglers was 14.5 hours. Dawn was considered to occur at 4 a.m.

By adding the number of hours expended by late-evening anglers, night anglers, and early-morning anglers it was estimated that an average of 73 fisherman-hours were expended each night between 8 p.m. and 6 a.m. This amounts to 7,811 fisherman-hours of angling pressure which were expended over the 107-day census. In 1958 the night fishing during the summer amounted to more than 15 percent of the total summer fishing pressure and 7 percent of the total annual fishing pressure. The importance of angling at night along the Des Moines River is emphasized by comparisons with other studies. On Fife Lake in Michigan night fishing amounted to less than 5 percent of the total fishing pressure (Eschmeyer, 1937). Boccardy [ca. 1953], however, found that night anglers constituted 13 percent of all anglers on Quabbin Reservoir in Massachusetts. Bullheads made up 67 percent of the total catch of these anglers.

The number of Des Moines River fishermen interviewed at night was too small to give a reliable estimate of catch per man-hour but fragmentary data collected in 1958, a poor year for channel catfish, indicates their rate of catch to have been between 0.10 and 0.15 fish per man-hour. This rate of catch was quite low and probably should be somewhat higher, at least during a good fishing year for channel catfish. Thompson and Hutson (1957) working on Lake Pawhuska, Oklahoma, observed night fishing for five years and found

that night anglers averaged 1.52 pounds per fishing trip, a better average than that for day fishermen. Channel catfish comprised approximately three-fourths of the night angler's creel on Lake Pawhuska. On Quabbin Reservoir night anglers averaged 1.19 fish per hour, approximately twice the mean rate of catch of daytime shore anglers.

Even though the data on night fishing are fragmentary, at the present time it is thought that the total estimate of night angling pressure was an underestimation of the actual amount expended. Wherever the channel catfish is the primary species sought a considerable number of the anglers seeking them will fish after dark, especially from 8 to 12 p.m. Channel catfish appear to feed more actively during the period from sundown until about midnight (Bailey and Harrison, 1948).

TAGGING RETURNS

The movements of channel and flathead catfish in the research area were studied by Muncy (1957) by means of an intensive tagging and recovery program. Reports from anglers indicated that tagged channel catfish traveled as far as 26 miles from tagging locations. Seven out of the 93 tags returned by anglers were from fish taken outside the 6.5-mile study area but the largest number of returns came from within one-half mile of the tagging locations. Muncy concluded that channel catfish appeared to follow no definite migration pattern but wandered considerably and changed their extent of movement during different times of the year. Data on flathead catfish also indicated no evident pattern in the movement of these fish in the Des Moines River.

The number of catfish tagged during 1957 and 1958, 259 channel and 31 flathead catfish, amounted to less than 10 percent of those tagged in the previous two years. Only 1 of the 64 channel catfish tagged in 1957 was recovered by an angler, and that in 1958. Of the 210 channel and flathead catfish tagged in 1958, 17 channel and 2 flathead catfish were recovered in the same year.

Some of the fish tagged prior to 1957 were also caught in 1957 and 1958. Anglers recovered two channel catfish in 1957 which were tagged in 1955. One flathead catfish, also tagged in 1955, was angled in 1958. Of those fish tagged in

1956, 43 channel and 1 flathead catfish were caught in 1957 and 6 channel and 2 flathead catfish were recovered in 1958.

Among those fish recovered in 1957, 27 had moved upstream, 12 downstream and four were found at the same location. The upstream migrants traveled an average of 2.2 miles while the downstream migrants ventured an average of 3.9 miles from their original tagging sites. One channel catfish was recovered as far as 11.75 miles upstream while four others were taken 6.25 miles downstream from the place at which they were tagged.

In the 1958 tagged-fish recoveries, the 16 downstream migrants traveled an average of 4.4 miles from their tagging sites and one fish was recovered 40 miles downstream. Only seven tagged fish were recovered upstream from their tagging sites, and they traveled an average of 1.9 miles. None of the upstream migrants had left the study area. Eight fish were recovered where they were tagged.

There were two notable features concerning the movement and recovery of tagged fish in 1957 and 1958. First of all, the movement of the downstream migrants was almost twice as far, on an average, as that of the upstream migrants. This suggests that the dams at Fraser and Boone may have acted as barriers to movement of fish migrating upstream at least during low water levels. Many tagged fish may have been prevented from leaving the study area by the Fraser Dam.

Also, tagged fish, once they went over the Boone Dam, were prevented from reentering the study area by the dam. However, both dams have fishways and undoubtedly many fish were able to get over the barriers. Secondly, in 1958 there were twice as many downstream migrants as there were upstream migrants. In fact, over 70 percent of all fish (8 out of 11) that were tagged for more than a year before recovery, were recovered downstream. Muncy also observed a predominance of downstream movements in 1955 but attributed this phenomenon to unequal netting intensity. In view of the small harvest of channel catfish in 1958, it is possible that more catfish could have migrated from the study area than into the area.

The tagging data give some information as to the minimum annual rate of harvest. Muncy (1957) estimated that the tag returns from fishermen represented a 3 percent return from all the channel catfish tagged. Considering only channel catfish over 9 inches in total length, the minimum size reported as kept by fishermen, the minimum rate of harvest was estimated as 4.6 percent. In the present study in 1958, 9 tags from a total of 194 tagged channel catfish were recovered by anglers. All of the fish tagged in that year were considered as being acceptable size to anglers. Therefore, the minimum annual rate of harvest was estimated as 4.6 percent, identical to that estimated by Muncy.

In 1958 a total of 43 walleyes were tagged. In less than one year, four tags were recovered by anglers which indicated a minimum annual rate of harvest for walleyes of 9.3 percent. These four walleyes traveled an average of 2.0 miles from their tagging sites. Manges (1950) found that returns from tagged walleyes ranged from 5.0 to 23.6 percent and averaged 17.4 percent in Norris Reservoir, Tennessee.

FACTORS AFFECTING THE HARVEST

The fisheries biologist is often asked to supply answers to why seasonal and annual harvests of fish and rates of harvest vary so markedly. These questions are difficult to answer with any degree of certainty because a complex of factors, many of which are closely correlated, usually causes the observed changes. The words of Solman (1951, p. 230) reflect the thoughts of many of the current workers in fishery management on this subject.

> A study of creel census information in conjunction with the results of limnological studies conducted during the same period of years has indicated clearly that while conventional methods of taking fish for study purposes will provide much information regarding fish populations and their ecology, they will not, in general, provide clear information about the relative availability of fish to the anglers.

Even in commercial fishery investigations the parameters used to estimate fish populations and harvest are not precise enough to permit accurate estimates of the expected harvest of fish (Watt, 1956).

The harvest of fish can be affected by changes in the amount of fishing and in the success of fishing and, thus, any factors which affect either of these affect the harvest.

Some Factors Affecting Fishing Pressure

According to other investigators, weather and its associated factors probably have a greater effect upon fishing

intensity from hour to hour and day to day than any other condition (Frey and Vike, 1941; Tarzwell and Miller, 1943; Cope, 1957). Neuhold and Lu (1957) demonstrated that inclement weather had a depressing effect on fishing pressure. They also reported that weather conditions at nearby centers of population affected the number of anglers fishing.

Some of the effects which meteorological factors have on fishing pressure are common knowledge and the findings of the present study corroborate the previous studies. For instance, on the Des Moines River in the fall and early spring, the heaviest fishing pressure coincided with the warmest parts of the day (Figures 9, 10, 12). Cool early-morning and late-evening air temperatures discouraged many anglers. Eschmeyer (1936) working on Fife Lake, Michigan, also found that fall fishing was concentrated in the late morning and early and mid-afternoon because of warmer air temperatures at those hours. Neuhold and Lu (1957) found that the number of fishermen appeared to increase as the temperature rose within the 60 to 80 degree Fahrenheit range.

Inclement weather often caused many fall and spring anglers to abandon their fishing trips on the Des Moines River. The bulk of the fishing early in the spring was done by experienced fishermen but as the air temperature grew warmer, family groups and the "occasional" fisherman swelled the total fishing pressure. In the fall, as air tempera-

tures became cooler, only the experienced anglers were encountered.

Many fishermen believe that changes in the water levels stimulate fish movement and fishing success. Most changes in the water levels on the Des Moines River produced a marked change in the amount of fishing pressure expended but not necessarily in the rate of catch. In situations where a small rise in the water level (more than 2 but less than 6 inches) took place in approximately a three-day interval, the fishing pressure dropped and the rate of catch increased in two out of three cases. When the water levels rose more than 6 inches, the fishing pressure and rate of catch dropped or remained the same in four out of five instances. A small drop in the water level (more than 2 but less than 6 inches) was accompanied by an increase in the fishing pressure in five out of six instances. Most fishermen believe that a small drop in the water level results in a better rate of catch. However, the rate of catch was definitely better in only three cases, and in two other instances, there was no difference in the rate of catch before or after the drop. Large drops in the water level always were accompanied by increased fishing pressure but no definite trend in the rate of catch was evident.

The reported success of anglers often has a subsequent effect upon the fishing pressure. In the last week of July

1958, fishing success for walleyes was good and fishermen passed this news to each other. This one week in the 86-day summer census absorbed over 15 percent of the total fishing pressure. In fact, on Tuesday of this week, 65 anglers were counted between 6 and 8 p.m. which was 30 percent higher than the average number of anglers counted on Sundays in the same time period. Neuhold and Lu (1957) found a significant difference in the mean number of fishermen between days following periods of good success and days following periods of poor success. The effect appeared to be somewhat delayed in that rate of success influenced fisherman numbers after occurrence rather than during occurrence. Similarly fisherman numbers, except for the opening hours of the day, appeared to be influenced by the rate of success in the preceding period. Lagler and DeRoth (1953) reported that some small ponds in Michigan experienced a drop in fishing pressure when fishermen passed the word that fishing was poor even though a good population of fish remained in these ponds.

Some Factors Affecting the Rate of Harvest

The effects which various factors may have upon the rate of harvest are not as easily predicted as some of the effects upon fishing pressure. Eschmeyer (1936) believed that the data on Fife Lake revealed no conclusive evidence of a close relationship between fishing success and several

meteorological factors. Muncy (1957) concluded that variation in hoop-net chatches on the Des Moines River were such that direct effects of single environmental factors such as water level or temperature could not be determined. Even though it was expected that the results would be meager, the creel-census data were examined in an attempt to correlate fishing success with several factors.

There was great similarity between seasonal fluctuations in the catch per man-hour in 1957 and 1958 (Figures 14 and 15). The highest catch per man-hour occurred during the first biweekly period in August, a time of the year when carp were creeled with relative ease. In August 1958, the rate of catch was higher than its counterpart in 1957, primarily because carp was the only species caught with regularity at this time. Since few channel catfish or game fish were available during August, most anglers turned for action to the more easily caught carp. After the first biweekly period in August the catch per man-hour steadily declined throughout the fall months until the first biweekly period in November when the rate of catch was less than one fish every five hours in 1957 and one fish every 10 hours in 1958.

The initial rate of catch in the early spring was low but it improved during May. In 1958, the rate of catch was very low in June and July, a time of the year when a good rate of catch is expected. However, high water levels and

Figure 14. Mean biweekly rate of catch, air temperature, and water temperature recorded on a 6.5-mile section of the Des Moines River, 1957.

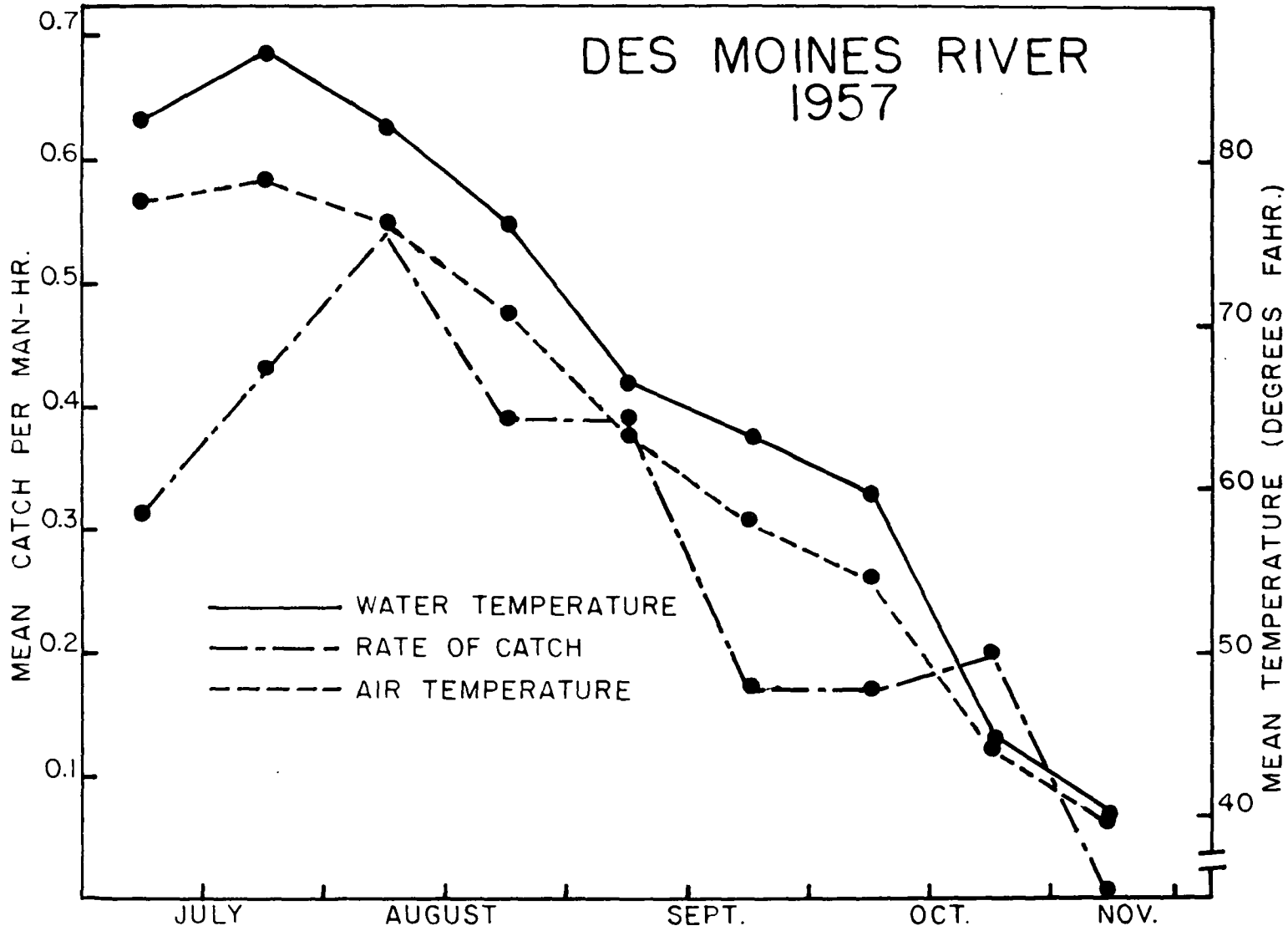
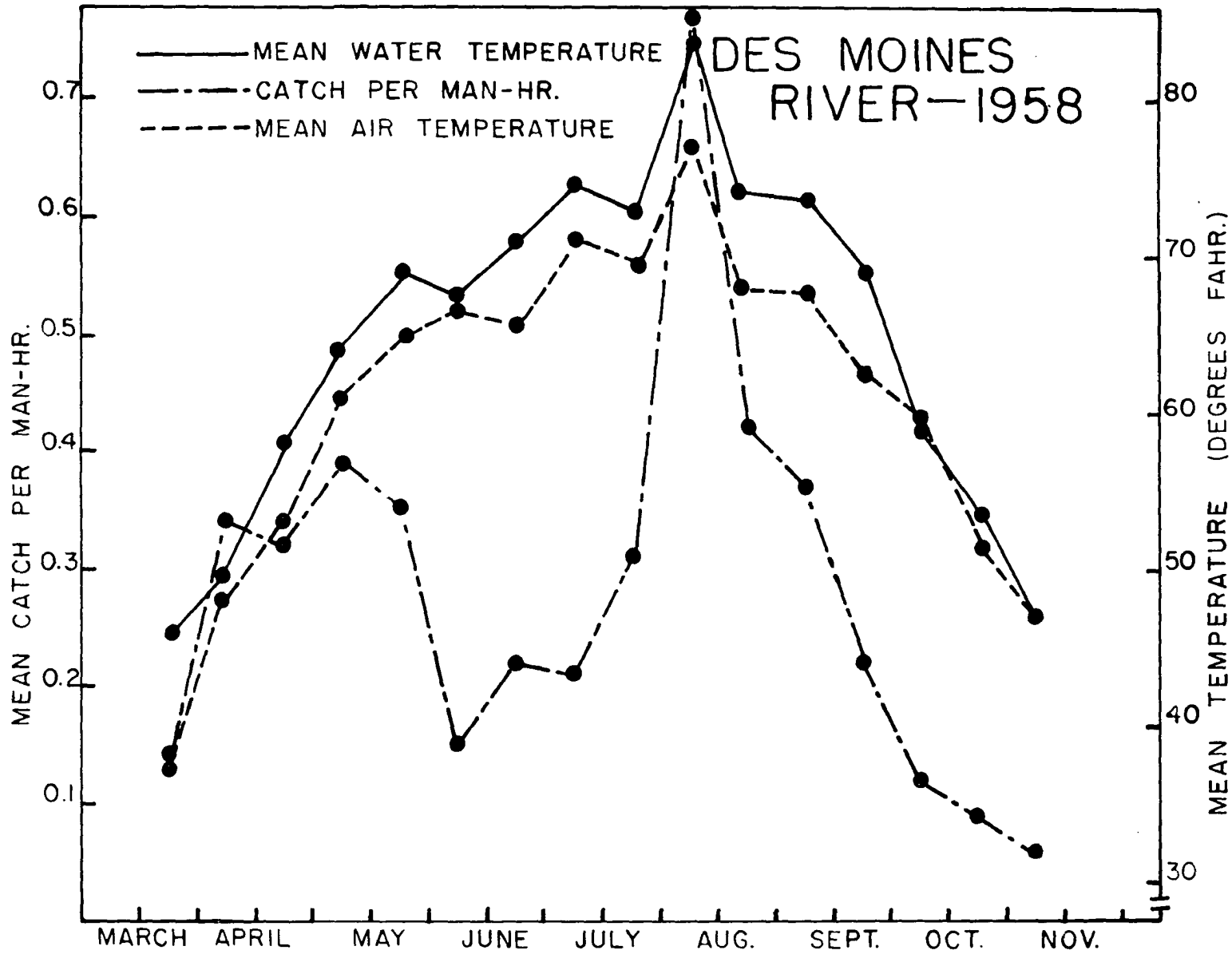

DES MOINES RIVER
1957
MEAN CATCH PER MAN-HR.
MEAN TEMPERATURE (DEGREES FAHR.)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
80
70
60
50
40
WATER TEMPERATURE
RATE OF CATCH
AIR TEMPERATURE
JULY
AUGUST
SEPT.
OCT.
NOV.

Figure 15. Mean biweekly rate of catch, air temperature, and water temperature recorded on a 6.5-mile section of the Des Moines River, 1958.


MEAN WATER TEMPERATURE
CATCH PER MAN-HR.
MEAN AIR TEMPERATURE
DES MOINES RIVER—1958
MEAN CATCH PER MAN-HR.
0.7
0.6
0.5
0.4
0.3
0.2
0.1
MEAN TEMPERATURE (DEGREES FAHR.)
80
70
60
50
40
30
MARCH
APRIL
MAY
JUNE
JULY
AUG.
SEPT.
OCT.
NOV.

frequent rains during this period probably had a depressing effect upon the catch per man-hour.

Temperature and rate of harvest

Because the Des Moines River is relatively shallow and not thermally stratified, it was thought that the air temperatures and water temperatures would be closely correlated. Figures 14 and 15 show that this is basically true, but the water temperatures during the summer were consistently a few degrees higher than the mean air temperatures. Water temperatures were taken primarily at the time of each creel-census count and were not taken every day, whereas air temperatures were averages for all days. This might result in greater variability of the mean biweekly water temperatures but should not have given consistently higher readings. It is known that in the summer mean daily soil temperatures taken near the soil's surface are consistently higher than the mean daily air temperatures (Shaw, 1959). Therefore, in a shallow river such as the Des Moines, it is not unreasonable to assume that water also stores a greater amount of solar radiation than the air and, consequently, the mean water temperatures would be higher than the mean air temperatures.

There is a general relationship between temperature and the rate of catch. The highest rate of catch occurred during the warmest biweekly period of the year (August 1 to 15)

and the lower rates of catch during the colder parts of the fishing year. Air and water temperatures undoubtedly were not the only factors influencing the higher rate of catch in August, however. Eschmeyer et al. (1946) concluded that water temperatures on T.V.A. lakes have a great influence on fisherman success. In 1945, an unusually warm March and unusually cool May extended the length of the spawning season of some game fish. The increased activity of the game fish, in conjunction with spawning, evidently increased their vulnerability to the angler, and fishing success in June was higher than usual. Dendy (1946a, 1946b) found that water temperature determined the depth distribution of fish in Norris Reservoir, Tennessee. In the spring, surface water temperatures above 60 degrees Fahrenheit produced the best fishing for largemouth bass because bass were found in the shallow water at that temperature. In the summer the depth distribution of fish was determined by the preferred water temperature of each species and the dissolved oxygen content of the water. Greenbank (1957) found a high degree of correlation between water temperature and weekly fishing success on the upper Mississippi River. Within a certain range, the higher the water temperature the better the fishing. However, extremely warm water may have been the cause of the mid-summer slump in fishing which, on the other hand, may have been caused by an increase in the available food supply

through the hatching of insects. Miller and Bryan (1947) found that the catch of crappie in hoop nets on T.V.A. reservoirs was related to the water temperature and the date of spawning. As the water temperature increased, the catch of crappie increased until mid-April when the peak of spawning occurred. After mid-April the rate of catch decreased.

Several authors (e.g., Eschmeyer et al., 1946; Miller and Bryan, 1947) have suggested that the rate of catch is affected by water temperature primarily because water temperature is a major spawning stimulus. In the Madison River, Montana, the rate of catch was generally higher in the fall than in the spring, even though fall water temperatures approached those at the start of the fishing season. Since rainbow and brown trout which usually spawn in late fall or early winter were the primary fish caught, the higher rate of catch of the fall anglers may have been partly due to increased activity of the fish preparatory to spawning (U.S. Fish and Wildl. Serv., 1954).

The various species of fish in the Des Moines River spawn at different times and therefore the effects of spawning activity can be evaluated if we look at the changes in the catch per effort for each species. The rate of catch for each species during each biweekly period was computed by dividing the total number of each species caught by the total number of hours expended by all fishermen, regardless of

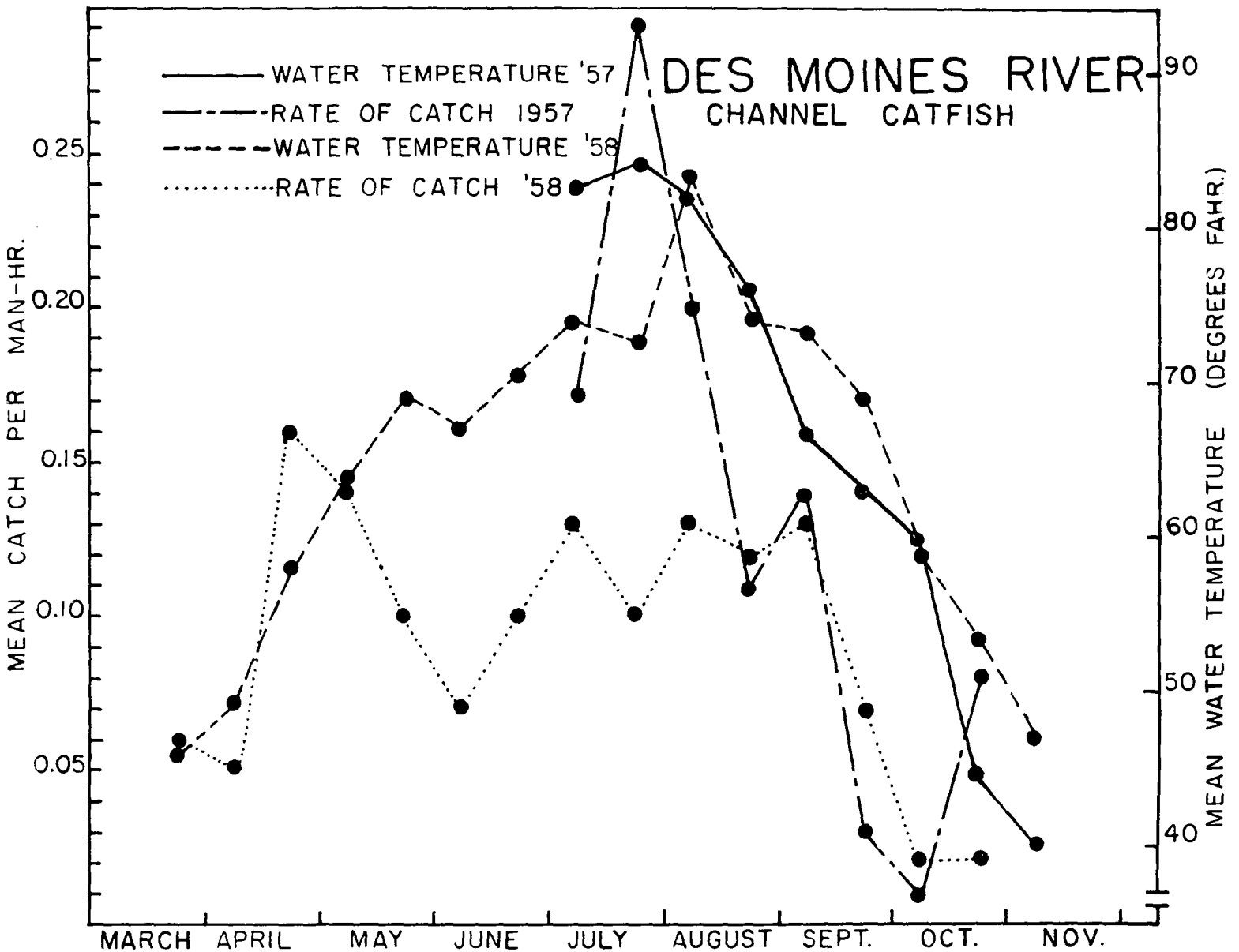
the species they intended to catch. Only the important species will be discussed in detail because the less important species were not caught in large enough numbers to be analyzed in a seasonal manner.

Channel catfish spawn after the water temperature reaches about 75 degrees Fahrenheit (Harlan and Speaker, 1956). Evidently the spawning season was quite long in 1958 because mature fish in breeding condition were observed from the middle of June to July 22. Harrison (1954b) found that channel catfish were caught at a much higher rate, 0.69 fish per hour, in June of 1953 than at any other month of the year. However, in 1954, catfish were caught at a higher rate in July. Air temperatures in the year 1953 were normal except that June was approximately four degrees warmer than the average June which probably precipitated spawning at a slightly earlier date. May of 1954 was marked by temperatures which were approximately five degrees Fahrenheit lower than the average for this month but June and July of that year enjoyed air temperatures which were slightly above normal. The cooler-than-average May probably slowed down the gonadal development of the channel catfish which delayed spawning for several weeks. Consequently, the difference in the 1953 and 1954 fishing peaks probably was due to a difference in spawning times during these two years. Muncy (1957) noted that greater numbers of adult channel catfish

(over 9 inches of total length) were taken in hoop nets from April to July than at any other time. The increased hoop-net catches were thought to be due to increased movement by spawning fish. However, Muncy observed that the hoop-net catches in late October and November also were quite good. Probably this latter increased catch was caused by fish which were seeking deep water in which to spend the winter. This fall movement of channel catfish apparently was not reflected in the anglers' catch, however (Figure 16). There was a slight indication in 1957 that fishing for catfish improved in late October but the size of the sample was small during this biweekly period and the observed increase may have been due to chance alone.

The rate of catch for channel catfish in 1957 was highest in the last two weeks of July when the catch reached 0.29 fish per hour. The rate of catch for channel catfish in June also may have been high but unfortunately the creel survey was not in operation during June. In 1958 the highest catch per man-hour was recorded during the last two weeks in April (0.16 fish). The moderately high rate of catch in April probably was caused by increased movements of channel catfish in search of food after a winter of relative inactivity. The rate of catch was low in May but appears to have been progressing toward a peak in July which was not achieved. High water levels and heavy rains were

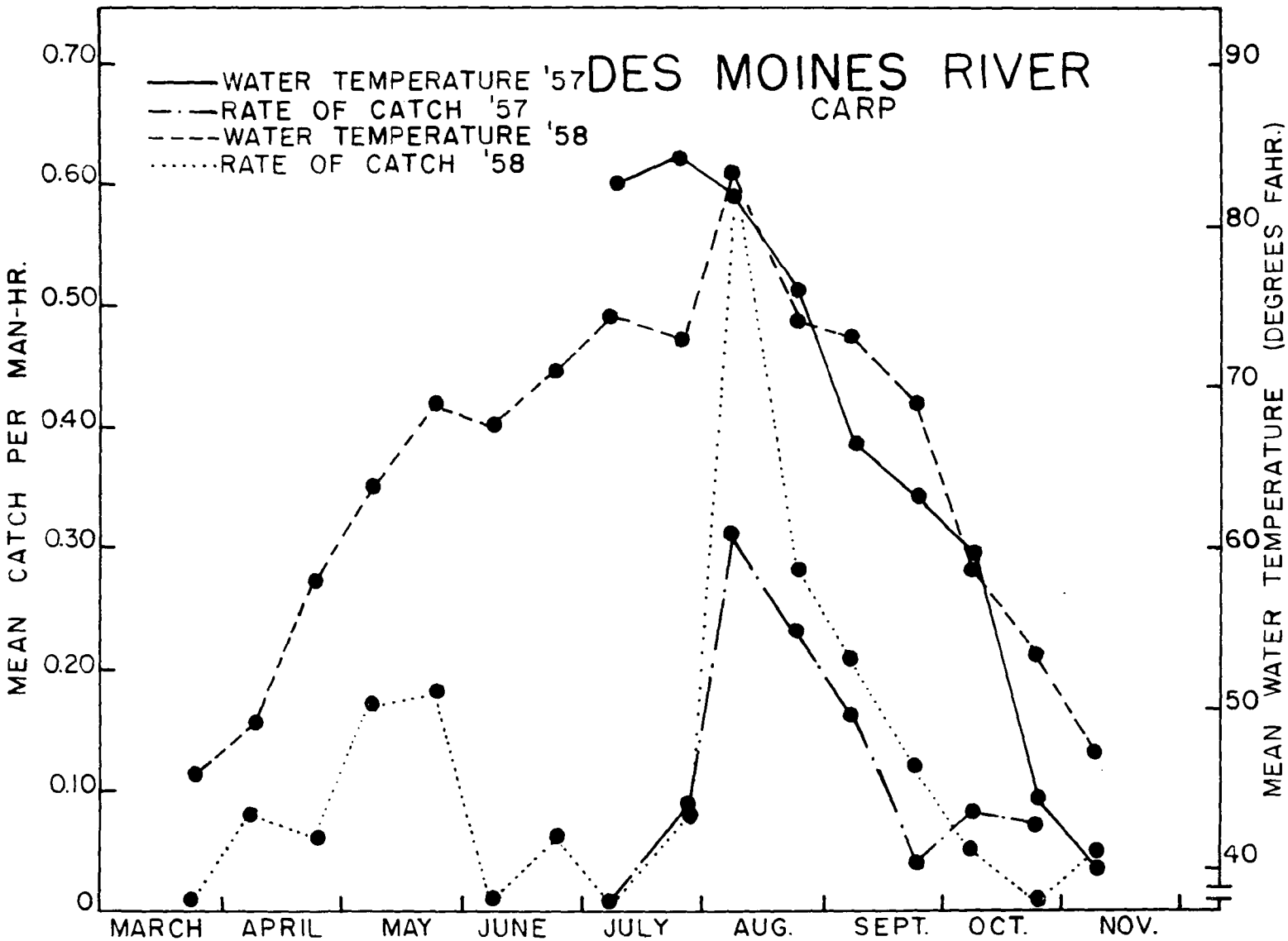
Figure 16. Mean biweekly rate of catch for channel catfish and mean biweekly water temperature recorded on a 6.5-mile section of the Des Moines River during 1957 and 1958.


DES MOINES RIVER
CHANNEL CATFISH
WATER TEMPERATURE '57
RATE OF CATCH 1957
WATER TEMPERATURE '58
RATE OF CATCH '58
MEAN CATCH PER MAN-HR.
0.25
0.20
0.15
0.10
0.05
MEAN WATER TEMPERATURE (DEGREES FAHR.)
90
80
70
60
50
40
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPT.
OCT.
NOV.

believed to be the cause for this lower-than-expected rate of catch in June and July. After September 15 of both years, the rate of catch was very low.

Carp usually spawn in late April or May in Iowa (Harlan and Speaker, 1956) although, in 1958, Des Moines River carp may have spawned in an erratic fashion over a long period of time (Rehder, 1959). Evidently the movement of carp due to spawning activities increased their vulnerability to the angler very little (Figure 17). There was a slight increase in the rate of catch of carp during May of 1958 but this increase was not great. The best time to catch carp in both 1957 and 1958 occurred in the first two weeks of August, approximately the time of the highest recorded water temperatures. Carp harvest, however, is also controlled by fisherman preference (Harrison, 1957b), and the high rate of catch of carp is probably, to some degree, the result of poor fishing for other species in the warmest weather. The recruitment of yearling carp into the fishery during August probably helps to improve the rate of catch in that month. A large percentage of the carp caught in August were approximately 8 to 10 inches in total length, usually the minimum size acceptable to carp fishermen. Rehder (1959) found that one-year-old carp averaged 9.7 inches in total length at time of capture. Therefore, at sometime during their second growing season, year-old carp began entering the fishery.

Figure 17. Mean biweekly rate of catch for carp and mean biweekly water temperature recorded on a 6.5-mile section of the Des Moines River during 1957 and 1958.

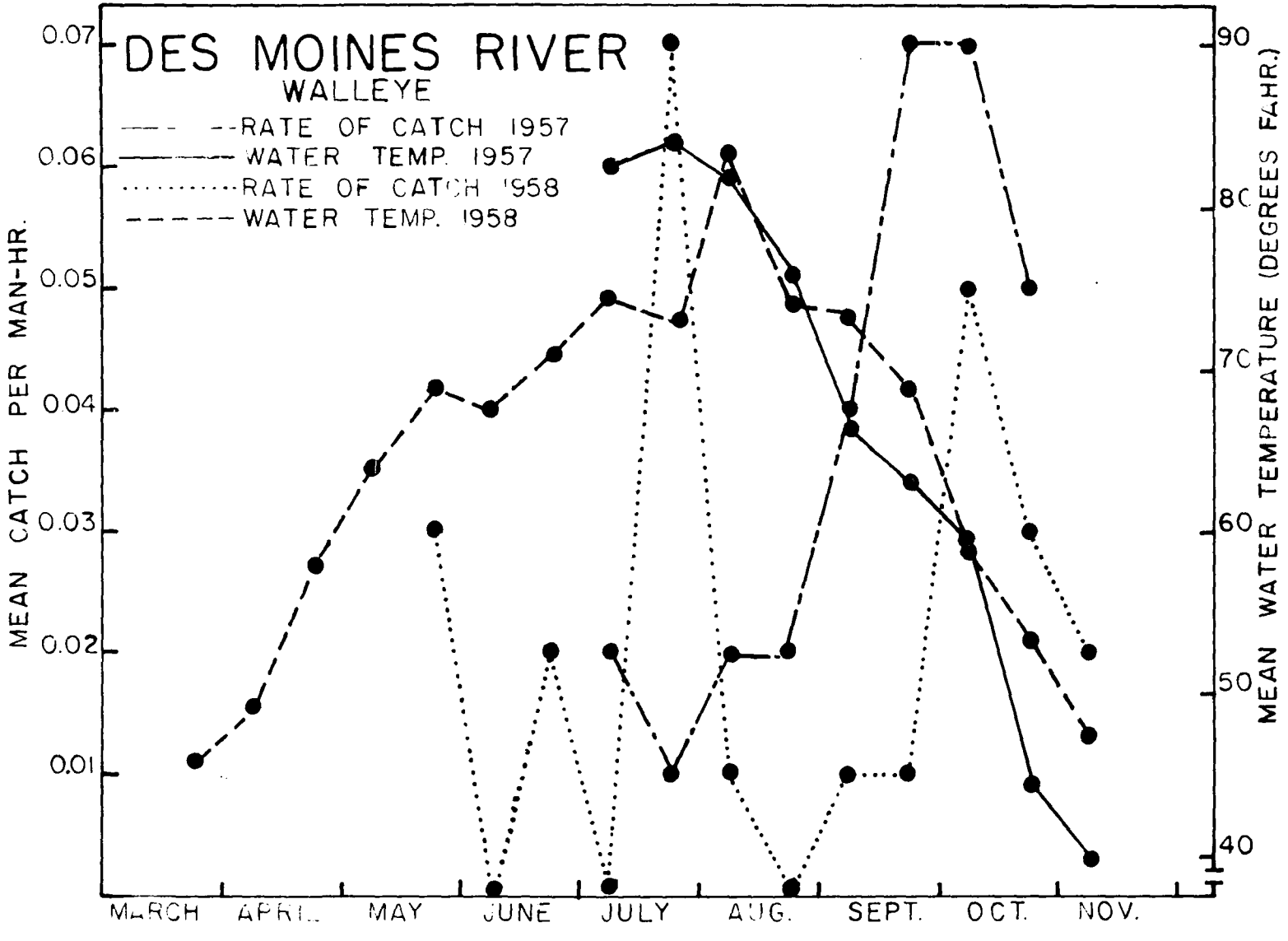

DES MOINES RIVER
CARP
WATER TEMPERATURE '57
RATE OF CATCH '57
WATER TEMPERATURE '58
RATE OF CATCH '58
MEAN CATCH PER MAN-HR.
MEAN WATER TEMPERATURE (DEGREES FAHR.)
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0
90
80
70
60
50
40
MARCH
APRIL
MAY
JUNE
JULY
AUG.
SEPT.
OCT.
NOV.

According to creel-census records in 1958 this took place primarily after June 15.

Walleyes spawn soon after the ice breaks up and when water temperatures reach 45 to 50 degrees Fahrenheit (Harlan and Speaker, 1956). Since the walleye season in Iowa opens during the second week in May when the water temperature is well over 60 degrees, spawning is completed before the opening day of the season. Many walleyes are caught and released before the opening day of the season, however, suggesting that fishing success would probably be good during and following spawning activity.

The rate of harvest of walleyes generally shows a definite seasonal pattern which is governed to a large extent by water temperatures. In both 1957 and 1958, some of the best fishing for walleyes, 0.07 and 0.05 fish per man-hour respectively, was recorded in the first biweekly period in October with a definite pickup occurring about September 15 (Figure 18). The mean water temperature around September 15 was approximately 60 degrees Fahrenheit. Actually the river does not freeze until after Christmas in most years, so that open-water fishing for walleyes in the fall would be possible up to that time. There is evidence that the rate of catch decreases in the fall as the water temperature drops below 55 degrees Fahrenheit. In general, walleye fishing ceases after November 15.

Figure 18. Mean biweekly rates of catch for walleye and mean biweekly water temperature recorded on a 6.5-mile section of the Des Moines River during 1957 and 1958.


DES MOINES RIVER
WALLEYE
--RATE OF CATCH 1957
WATER TEMP. 1957
RATE OF CATCH 1958
WATER TEMP. 1958
MEAN CATCH PER MAN-HR.
0.07
0.06
0.05
0.04
0.03
0.02
0.01
MEAN WATER TEMPERATURE (DEGREES FAHR.)
90
80
70
60
50
40
MARCH
APRIL
MAY
JUNE
JULY
AUG.
SEPT.
OCT.
NOV.

The increased activity of walleyes in the fall was not due to spawning but probably to increased feeding. The growth pattern of the Des Moines River walleyes (Schmulbach, in press) substantiates the opinion that the reason for increased rate of catch in the fall months is due to more activity associated with feeding. During mid-summer adult walleyes grow very little indicating that they are feeding very little. Most growth occurs in late spring and early fall. Stroud (1949) found that seasonal growth among walleyes in age groups I through IV varied between the age groups but, in general, the greatest seasonal growth was observed in late spring and again in late summer. Little or no growth occurred in mid-summer in the Tennessee reservoir.

In general walleyes prefer cool water. At least they are intolerant of high water temperatures. In thermally stratified T.V.A. lakes, walleyes preferred water temperatures of approximately 70 to 75 degrees during the summer (Dendy, 1946b). The Des Moines River is marginal habitat for walleyes because water temperatures above 90 degrees, which often prove fatal to this species, are not uncommon. One reported fish kill due to high water temperatures occurred in July 1955 and, apparently, decimated the walleye population in certain reaches of the river (Muncy, 1956; Harrison, 1957b). However, following the summer kill of

1955 walleyes made a strong resurgence and displayed excellent growth and survival in 1956 and 1957 (Schmulbach, in press). Since the Iowa Conservation Commission has annually stocked young walleyes in the Des Moines River in Boone County, it was difficult to state whether the young walleyes in the 1956 and 1957 year classes were naturally spawned.

Fishermen angling during the last two weeks in July 1958, were surprised to find walleyes biting with mid-October fervor. This period of good walleye fishing (0.07 fish per man-hour) lasted for approximately a week (July 25 to July 31), but fishermen took many large walleyes during this period. This increased walleye activity was also noticed in the netting and shocking operations. On July 21, 11 walleyes, the highest number taken in a single day with the electrical shocker, were captured, tagged, and released. The existing environmental conditions did not suggest a reason for this better-than-expected rate of catch. The water level was dropping and the water transparency was improving but neither of these factors were unusual or extreme. July 1958, with over 10 inches of rainfall, was the wettest July on record. The entire month had been quite cool with the average air and water temperatures far below normal. On July 20, the rainy weather ceased and the river began to drop. The water also became warmer and more transparent. The walleye fishing showed pronounced improvement at that

time. However, on August 1, the only hot spell of the summer occurred in central Iowa, air temperatures exceeded 90 degrees Fahrenheit, and walleyes stopped biting almost immediately.

Suckers (mostly northern and golden redhorse) are important to the Des Moines River fishery during the early spring months, at the time of their general spawning activity (Harlan and Speaker, 1956). It is generally believed that suckers do not readily bite on baited hooks. However, in the early spring of 1958 the rate of catch for suckers reached a high of 0.21 fish per hour. This was the only time of the year when suckers were particularly vulnerable to the angler. Of course, one cannot discount the possibility that angler preference played a minor role in the annual rate-of-catch pattern for suckers. Many anglers in the spring intentionally fish for suckers with worms on small hooks. Often these suckers are subsequently used as bait for channel catfish but, in 1958, suckers were sometimes sought because they were the only fish which could be caught with regularity. Later in the season when other species of fish were readily caught, no one was observed fishing for suckers.

Most of the bullheads were caught in June and July after their spawning period was over. Bullheads spawn in May and early June (Harlan and Speaker, 1956). Water levels

Water level, turbidity and rate of harvest

Water levels and turbidity due to the suspension of soil particles are closely correlated. When water levels are high, turbidity is usually high, resulting in low Secchi-disc readings (Figure 19). The Secchi-disc readings were more variable than the water levels because local rains affect the transparency of the water even though they may not have much effect upon the mean biweekly water levels. The transparency of the water is probably a more important influence than water level on the rate of catch of walleyes in the fall. However, since these factors are closely related, they will be discussed together.

On the Des Moines River there was no consistent relationship between the mean rate of catch and the mean water-level readings (Figure 20). However, in the spring and summer of 1958 the mean rate of catch was lowest when Secchi-disc readings were lowest and water levels highest (June 1 to 15).

The catch of bullheads in the study area was restricted mostly to the months of June and July. In 1957, the only year in which many bullheads were recorded in the catch, the rate of catch for bullheads was highest when water levels were highest. There appears to be a correlation between water levels and the rate of catch of bullheads but the data are not complete for the entire year. However, this same

and turbidity are believed to be more significant in determining the rate of catch for bullheads than any other factor.

Flathead catfish were caught in greatest numbers during the late spring and early summer months. In 1958, 75 percent of all the flatheads caught were angled before the first of July. Since flathead catfish spawn in June and July (Harlan and Speaker, 1956), spawning activity may be a factor in their capture at this time. Also, fishermen seeking flathead catfish believe that these fish bite better when the river is turbid and rising slowly. Iowa receives much of its summer rainfall in May, June and early July and therefore turbid water occurs more frequently at this time of the year. The combined effect of increased fishing pressure and vulnerability probably account for the increased catch of flathead catfish in May, June and early July.

Smallmouth bass spawn when the water temperature reaches about 60 to 65 degrees Fahrenheit (Harlan and Speaker, 1956). Since the bass season in Iowa does not open until past the middle of May, much of the spawning may be completed before the season opens. There appeared to be no definite pattern to the catch rate for smallmouth bass, although very few were caught when water temperatures exceeded 80 degrees Fahrenheit. Considering both years, only 3 out of the total number of 46 smallmouth bass were taken during the first biweekly period in August.

Figure 19. Mean biweekly Secchi disc reading and water level stage recorded on a 6.5-mile section of the Des Moines River, 1958.

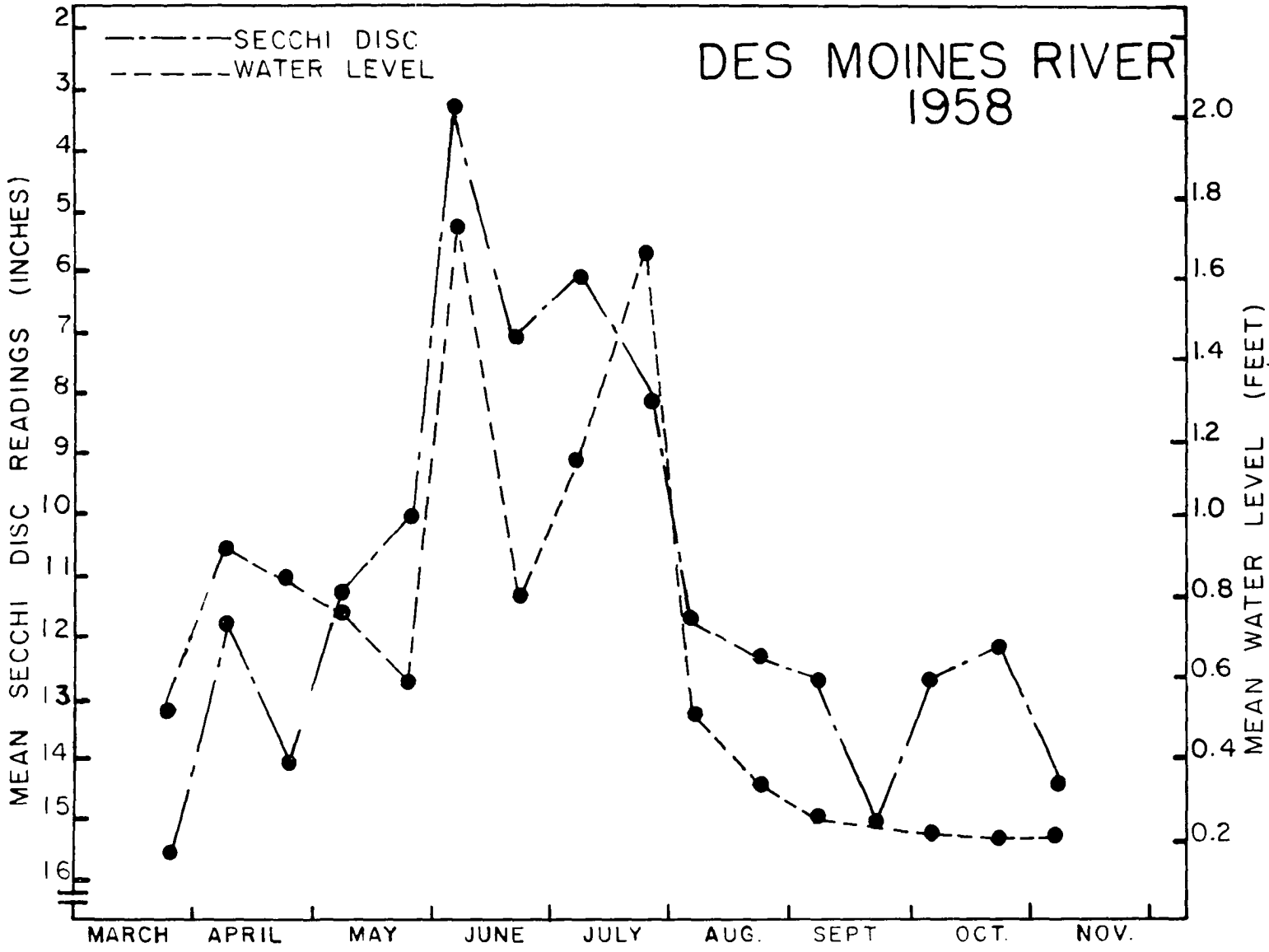
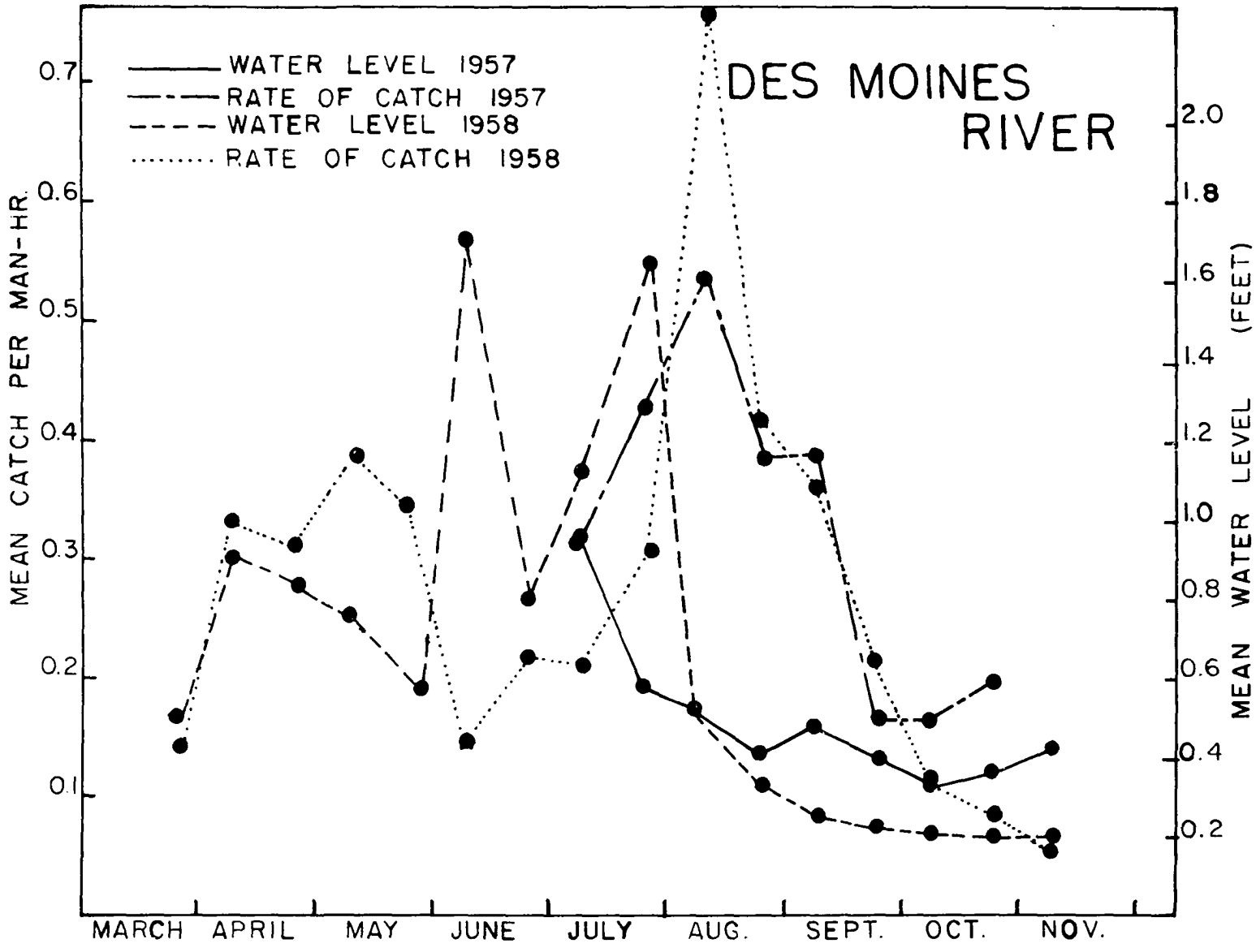

SECCHI DISC
WATER LEVEL
DES MOINES RIVER
1958
MEAN SECCHI DISC READINGS (INCHES)
MEAN WATER LEVEL (FEET)
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
MARCH
APRIL
MAY
JUNE
JULY
AUG.
SEPT
OCT.
NOV.

Figure 20. Mean biweekly rate of catch and water level stage recorded on a 6.5-mile section of the Des Moines River during 1957 and 1958.


WATER LEVEL 1957
RATE OF CATCH 1957
WATER LEVEL 1958
RATE OF CATCH 1958
DES MOINES RIVER
MEAN CATCH PER MAN-HR.
MEAN WATER LEVEL (FEET)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
MARCH
APRIL
MAY
JUNE
JULY
AUG.
SEPT.
OCT.
NOV.

relationship may be expressed as a negative correlation between Secchi-disc readings and catch per man-hour. Bullheads are guided in their feeding by a keen sense of smell which probably gives them an advantage in turbid water over most species of fish. High water levels and turbid water would not be a hindrance to bullheads in the gathering of food and may, in fact, reduce much of the competition from other fish for food.

Low water levels and increased transparency may also have a beneficial effect upon the catch per man-hour, at least in the case of certain sight-feeding game fish. The rate of catch of walleyes in the Des Moines River improved during the fall when the transparency of the water was greatest. Lakes Waubesa and Kegonsa, Wisconsin, experienced some cold windy weather in July of 1939 which dropped the temperature, made oxygen available, and eliminated much of the free carbon dioxide. The algal bloom was also broken up, greatly improving the transparency and also the fishing success (Frey and Vike, 1941). Harrison (1954), in a preliminary report, suggested a correlation between the success of fishermen seeking catfish and the "pattern" of the stream stage on the Des Moines River but has made no further report on that relationship. On T.V.A. reservoirs, Tarzwell (1942) observed that when the water levels were high and maintained at a constant level, these conditions were considered best

for fishing by the fishermen although the catch per hour was often higher when these conditions did not prevail. High water was conducive to higher catches in hoop nets in the Big Muddy River, Illinois (Lewis, 1955). On the other hand, lower, more stable water conditions coincided with increased fishing success on the Mississippi River (Greenbank, 1957).

Changes in water levels are often important to fishing success. As previously stated, a small drop or rise (more than 2 but less than 6 inches) in the water level was generally accompanied by an increase in fishing success. A large drop or rise (more than 6 inches) in the water level usually was accompanied by a drop in the rate of catch or resulted in no change in the catch per man-hour. Starrett and McNeil (1952) noticed that fishing was consistently poor during periods of low stable water-levels in Lake Chautauqua, Illinois. More fish were caught during periods of rising and high water-stages. There was a positive correlation between rising water levels and an increase in the catch of most fish and especially channel catfish. However, fishing for largemouth bass was best when water levels were either falling or at a low stable stage.

Population fluctuations and rate of harvest

In any fishery the existing fish populations change from year to year. This is especially true if the body of water is marginal habitat for some members of its fish

population. The effects of the 1956 dominant year class of walleyes, after a summer kill of walleyes in 1955, was noted in the Des Moines River (Schmulbach, in press). In 1957, yearling walleyes were present in the catch and by 1958 most walleyes from the 1956 year class were an acceptable size to anglers. No doubt this year class has had a profound influence upon the rate of catch of walleyes in the Des Moines River. Other studies (Frey et al., 1939; Wood et al., 1956) observed that a decline in the rate of catch was attributable to a decline in the abundance of an important species of fish.

Fishermen often compensate for changes in the fish population by shifting their emphasis to a more readily available species. Several investigators have noted that a decrease in the catch of one species resulted in an increase in the catch of other species (Boussu and Clothier, 1954; Jackson, 1958).

Angler behavior and rate of catch

There are many factors affecting the rate of harvest which are attributable to the caprice and skill of the fishermen. Some of these factors have been mentioned in previous discussion but there appears to be no way to evaluate properly their effect on the harvest. The skilled anglers consistently catch fish even when others fail. They modify their fishing technique to meet the changes in the habits

of the species sought, even if it requires much effort. Greenbank (1957) stated that early-morning fishing was best on the Mississippi River but apparently only the inveterate fishermen were willing to start fishing early or stay late. This may also be true on the Des Moines River. Fishing pressure was light during the early-morning period in all seasons, and this small amount of fishing pressure appears to be justified since the rate of catch in the early morning was usually low (except in the fall of 1957, Figure 9). However, early-morning anglers were usually good fishermen who were seeking only channel catfish and game fish and accepted no small fish in their creel.

The skill of the angler is very important and has a noticeable effect upon the total harvest of a fishery. On the Potomac River, 37 percent of the total catch was taken by 10 percent of the fishermen. Fleener (1952) found that 6.4 percent of the fishermen on the Big Piney River, Missouri, caught over 18 percent of the total number of smallmouth bass. According to Thompson and Hutson (1951), more skilled fishermen may have been a factor in determining better fishing success during fall and early winter months on Lake Pawhuska, Oklahoma. Hcuser and Heard (1958) noticed that local skilled anglers were encountered frequently and they caught the larger bass on Fort Gibson Reservoir, Oklahoma. Neuhold and Lu (1957) found that the more trips

a fisherman made, the better was his rate of catch. In general, there appears to be a close correlation between the number of fishing trips per season and the rate of success of the angler.

Angler prejudice also has a noticeable effect upon the harvest. On the Des Moines River, angler preference was incriminated as a contributing cause in the pattern of harvest of carp and suckers. When catfish and game fish were not biting, anglers turned to carp or suckers for action. Suckers were taken by anglers primarily in the early spring before channel catfish were caught in great numbers and before the opening of the season for walleyes and smallmouth bass. Good fishing for channel catfish usually begins in June and terminates by the first of August. After this time channel catfish are no longer readily available but carp are available and their vulnerability may be increased by warmer water temperatures. Consequently, fishermen turn to carp for action. In the month of September the thoughts of anglers turn towards game fish such as walleyes and, once again, the carp becomes a "forgotten" fish. If the same amount of effort were expended to catch carp during all periods of the year, the catch per man-hour of carp in May, June, July, and September would probably be much higher than that observed.

SUMMARY

1. Creel census data were collected on a 6.5-mile section of the Des Moines River lying between the lowhead dam at Fraser and the Water Works Dam at Boone (Boone County, Iowa) to secure a satisfactory estimate of the angling pressure, determine the characteristics of the Des Moines River fishery, and evaluate the factors which affect the harvest of fishes.

2. The survey, July 7 to November 12, 1957, and March 22 to November 16, 1958, was broken into five seasonal periods. A Latin-square sampling scheme was modified for use in estimating angling intensity. The anglers were personally contacted in an effort to estimate the rate of catch and species composition of the catch. Most anglers were interviewed while they were actively fishing. Approximately 3,250 boat and shore fishermen and waders were interviewed during the five seasons.

3. No relationship could be demonstrated between catch per unit of effort and length of the fishing trip although fishing trips over 7 hours long did have lower-than-average rates of catch. Likewise there was no significant relationship between rate of catch and percentage of the fishing trip completed up to the time the interview took place. Therefore, sampling fishermen before they finished should give a satisfactory estimate of catch per hour.

4. Estimates of the rate of catch obtained from incompleted fishing trips were not significantly different at the 95 percent probability level from those obtained from completed fishing trips ($X^2 = 6.864$; d.f. = 4).

5. The amount of fishing pressure had no significant effect upon fishing success ($r = 0.146$; d.f. = 49), although there was an indication that very high fishing pressure was associated with slightly lower rates of catch.

6. Estimates of the total fishing pressure and rate of catch could be made more precise by increasing the number of counts and interviews during the more heavily-fished seasons, days of the week, and periods of each day after these periods were defined. In the last four seasonal periods, week-end days were therefore sampled more heavily than week days.

7. Week-end days and especially Sundays were fished much more heavily than weekdays. This was due primarily to the presence of family groups who combined their fishing trip with a family outing. During the spring and fall seasons the greatest amount of fishing pressure occurred in the mid-afternoon but in the summer the late-evening was the most heavily-fished time of the day.

8. The Des Moines River is heavily fished and during an average year the total amount of daylight fishing pressure could be expected to average between 10,000 and 13,077

fisherman-hours per mile or between 363 and 475 fisherman-hours per acre.

9. The mean rate of catch was quite low during the course of this study, 0.38 fish per man-hour. Boat fishermen enjoyed the best success (0.49 fish per man-hour) while waders caught the fewest fish per hour (0.28 fish).

10. In the five seasons censused the catch of channel catfish and carp comprised between 73.0 and 88.5 percent of the total catch in numbers. Walleyes were important in the total catch only in the fall while suckers belonging primarily to the genus Moxostoma were important only in the spring.

11. It was estimated that approximately 119.4 pounds of fish per acre which is equivalent to 3,312 pounds of fish per mile were harvested in 1958, a rather poor fishing year. Carp comprised 51.8 percent of the total weight of the harvest.

12. Over 87 percent of the anglers contacted lived within a 20-mile radius of the point of interview. Men averaged 72.7 percent, women 14.9 percent, boys 10.4 percent and girls 2.0 percent of the total number of anglers contacted. Men were more successful fishermen than women. Bait casting rods were overwhelmingly the most popular type of rod and comprised 68.7 percent of all rods. Some of the most successful baits for channel catfish were chicken

entrails and liver while doughballs were the most successful carp bait.

13. At least 40 percent of all anglers were not particular about which species they caught. During the fall seasons anglers seeking game fish (primarily walleyes) comprised over 25 percent of the total number of anglers. The number of anglers seeking carp consistently approximated 10 percent of all anglers but their rate of catch was more than twice as great as any other group of fishermen.

14. There was no apparent difference between the rate of success of fishermen using one or two lines (Iowa law permits the use of two lines).

15. A considerable amount of angling takes place after dark and in 1958 an estimated 7,811 fisherman-hours of angling pressure were expended over an 107-day census (May 15 to September 1) in addition to that covered by the daytime creel census. This amounted to more than 15 percent of the total summer fishing pressure and 7 percent of the total annual fishing pressure. Most night anglers were seeking catfish.

16. Returns from tagged fish indicated the minimum rate of harvest of channel catfish as 4.6 percent and of walleye as 9.3 percent. One channel catfish traveled as far as 40 miles downstream from its tagging site, but most were taken near the tagging sites.

17. Weather and its associated factors probably have a greater effect upon fishing intensity than any other condition. In the fall and early spring the heaviest fishing pressure coincided with the warmest parts of the day. Inclement weather often caused many fall and spring anglers to abandon their fishing trips.

18. Changes in water levels produced marked changes in the amount of fishing pressure but not necessarily the rate of catch. Where a small rise in the water level took place, fishing pressure always dropped and the rate of catch increased in two out of three cases. When large rises in water level occurred, fishing pressure and the rate of catch dropped or remained the same in four out of five instances. Small drops in the water level were accompanied by increased fishing pressure in five out of six instances but the rate of catch was definitely better in only three cases. Large drops in the water level were always accompanied by increased fishing pressure but no trend in the rate of catch was evident.

19. There was a general relationship between temperature and rate of catch. The highest rate of catch occurred during the warmest biweekly period of the year and the lower rates of catch during the colder parts of the fishing year.

20. It appears that the rate of catch is affected by water temperature primarily because water temperature is a

major spawning stimulus. Increased activity of the fish in conjunction with spawning evidently increases their vulnerability to the angler. The highest rate of catch of channel catfish usually occurs in June and July which is approximately the spawning season for these fish. Suckers were important to the Des Moines River fishery only during the spring months at the time of their general spawning activity.

21. The best time to catch carp occurred at approximately the time of the highest recorded water temperatures. Carp harvest is also controlled by angler preference and the higher rate of catch of carp is probably the result of poor fishing for other species in the warmest weather.

22. Walleyes were caught at a higher rate in the fall when water temperatures were approximately 60 degrees Fahrenheit. This increased catch was due to increased feeding activity which probably was initiated by more favorable water temperatures.

23. The rate of catch for bullheads was highest when water levels and turbidity were high. High water levels and turbid water do not hinder bullheads in gathering food and may reduce much of the competition from other fish.

24. Angler preference was a contributing cause in the pattern of harvest of carp and suckers. When catfish and

game fish were not biting, anglers turned to carp or suckers for action.

LITERATURE CITED

Allen, R. K.
1951. The Horokiwi Stream, a study of a trout population. Wellington, New Zealand. New Zealand Marine Dept. Fish. Bul. No. 10.

Bailey, Reeve M. and Harry M. Harrison
1948. Food habits of the southern channel catfish (Ictaluris lacustris punctatus) in the Des Moines River, Iowa. Trans. Am. Fish. Soc. 75: 110-137.

Bennett, George W. and Leonard Durham
1951. Cost of bass fishing at Ridge Lake, Coles County, Illinois. Ill. Nat. Hist. Surv. Biol. Notes No. 23.

Best, E. A. and H. D. Boles
1956. An evaluation of creel census methods. Calif. Fish and Game Vol. 42, No. 2: 109-115.

Bishop, Clinton G.
1955. Census of fisherman's creels and analysis of creel census data. (Mimeo.) Mont. State Dept. of Fish and Game. Job Comp. Rept. F-4-R-4.

Boccardy, Joseph A.
[ca. 1953]. A season's creel census on Quabbin Reservoir, Massachusetts. (Mimeo.) Mass. Div. of Fish. and Game. Dingell-Johnson Proj. F-6-R.

Boussu, Marvin F. and William D. Clothier
1954. A fisheries report on Lake Madison. So. Dak. Conserv. Digest Vol. 21, No. 4: 9-11.

Buchholz, Marvin M.
1957. Age and growth of river carpsucker in Des Moines River, Iowa. Proc. Iowa Acad. Sci. 64: 589-600.

Calhoun, A. J.
1950. California angling catch records from postal card surveys: 1936-1948; with an evaluation of postal card nonresponse. Calif. Fish and Game Vol. 36, No. 3: 177-234.

Carlander, Kenneth D.
1953. Handbook of freshwater fishery biology, with first supplement. Dubuque, Iowa. Wm. C. Brown Co.

Carter, Ellis R.
1957. Investigations and management of the Dewey Lake fishery. 10th Conf. Southeastern Assoc. of Game and Fish Commissioners Proc.: 254-270. (Reprint)

Clark, Clarence F., E. Dean Now, and John Flinn
1948. A progress report of the creel census at Lakes St. Marys and Loramie, Ohio, 1946. Ohio Jour. Sci. Vol. 48, No. 1: 41-48.

_____, D. Allison, and R. McElroy
1952. A progress report on the creel census and fish harvest on Riley Creek, Ohio for the years 1950 through 1952. (Offset) Ohio Div. Wildl.

Cleary, Robert E.
1953. A modified voluntary creel census on Northeast Iowa streams. Iowa State Conserv. Comm. Quart. Biol. Rept. Vol. 5, No. 1: 1-8.

_____.
1956. An appraisal of a modified voluntary creel census as used on Northeast Iowa streams. Symposium on Sampling Problems in Creel Census. Ames, Iowa. Iowa Coop. Fish. Res. Unit: 39-41.

Clothier, William D. and Marvin F. Boussu
1954. The 1953 voluntary warden creel census. So. Dak. Conserv. Digest Vol. 21, No. 5: 8-11.

Cooper, Edwin L.
1952. Rate of exploitation of wild eastern brook trout and brown trout populations in the Pigeon River, Otsego County, Michigan. Trans. Am. Fish. Soc. 81: 224-234.

_____.
1953. Returns from plantings of legal-sized brook, brown, and rainbow trout in the Pigeon River. Trans. Am. Fish. Soc. 82: 265-280.

Cope, Oliver B.
1957. Six years of catch statistics on Yellowstone Lake. Trans. Am. Fish. Soc. 85: 160-179.

Dendy, Jack S.
1946a. Water temperature and spring fishing, Norris Reservoir, Tennessee. Jour. Tenn. Acad. Sci. Vol. 21, No. 1: 89-93.

———.
1946b. Further studies of depth distribution of fish, Norris Reservoir, Tennessee. Jour. Tenn. Acad. Sci. Vol. 21, No. 1: 94-104.

DiCostanzo, Charles James
1956. Creel census techniques and harvest of fishes in Clear Lake, Iowa. Unpublished Ph. D. Thesis. Ames, Iowa. Library, Iowa State University of Science and Technology.

——— and Richard L. Ridenhour
1957. Angler harvest in the summers of 1953 to 1956 at Clear Lake, Iowa. Proc. Iowa Acad. Sci. 64: 621-628.

Elser, Harold J.
1954. Fishing pressure and the harvest of sport-fishes on the Potomac River in 1954. (Mimeo.) Md. Dept. Res. and Ed.

Eschmeyer, R. William
1936. Analysis of the game fish catch in a Michigan Lake. Trans. Am. Fish. Soc. 65: 207-223.

———.
1937. A second season of creel census on Fife Lake. Trans. Am. Fish. Soc. 66: 324-334.

———.
1939. Summary of a four-year creel census on Fife Lake, Michigan. Trans. Am. Fish. Soc. 68: 355-358.

———.
1942. The catch, abundance, and migration of game fishes in Norris Reservoir, Tennessee, 1940. Jour. Tenn. Acad. Sci. Vol. 17, No. 1: 90-115.

_____, D. E. Manges, and O. F. Haslbauer
1946. Spring fishing on several T.V.A. storage reservoirs, 1945. Jour. Tenn. Acad. Sci. Vol. 21, No. 1: 78-88.

_____ and Lawrence F. Miller
1949. Fishing in T.V.A. tailwaters. Norris, Tennessee. Tenn. Valley Authority.

Fleener, George G.
1952. An intensive creel census of two similar smallmouth bass streams in the Missouri Ozarks. (Mimeo.) Paper presented at the 14th Ann. Midwest Wildl. Conf., Des Moines, Iowa, Dec. 18, 1952. Missouri Conserv. Comm.

Frey, David G., Hubert Pedracine, and Lawrence Vike
1939. Results of a summer creel census of Lakes Waubesa and Kegonsa, Wisconsin. Jour. Wildl. Mgt. Vol. 3, No. 3: 243-254.

_____ and Lawrence Vike
1941. A creel census on Lakes Waubesa and Kegonsa, Wisconsin, in 1939. Trans. Wisc. Acad. Sci., Arts and Letters 33: 339-362.

Fry, F. E. J.
[ca. 1949]. Methods of creel census and angling returns. (Mimeo.) Ont. Fish. Res. Lab., Dept. of Zoology, Univ. of Toronto.

_____.
1949. Statistics of a lake trout fishery. Biometrics Vol. 5, No. 1: 27-67.

Fukano, K. C.
1948. General creel census of fishing, 1947. Mich. Conserv. Vol. 27, No. 12: 8,9,15.

Greenbank, John
1957. Creel census on the upper Mississippi River. Dept. of the Int., U.S. Fish and Wildl. Serv. Spec. Sci. Rept. Fish. No. 202.

Hale, J. G.
1952. An investigation of survival to the creel from three plantings (April, June, July) of marked yearling brook trout (Salvelinus fontinalis Mitchill), catch of "resident" fish and of trout

populations in the west branch of the Split Rock River, 1952. (Mimeo.) Minn. Dept. Conserv., Fish. Res. Unit Invest. Rept. No. 132.

Harlan, James R. and Everett B. Speaker
1956. Iowa Fish and Fishing. 3rd ed. Des Moines, Iowa. Iowa State Conserv. Comm.

Harrison, Harry M.
1953. Creel census of the upper Des Moines River for the spring and early summer of 1953. (Mimeo.) Iowa Conserv. Comm. Quart. Biol. Rept. Vol. 5, No. 2: 65-69.

———.
1954a. Smallmouth bass studies, Des Moines River. (Mimeo.) Iowa Conserv. Comm. Quart. Biol. Rept. Vol. 5, No. 4: 6-11.

———.
1954b. A preliminary report on the Des Moines River creel census. (Mimeo.) Iowa Conserv. Comm. Quart. Biol. Rept. Vol. 6, No. 3: 43-47.

———.
1956. Des Moines River creel census, 1956. (Mimeo.) Iowa Conserv. Comm. Quart. Biol. Rept. Vol. 8, No. 4: 38-40.

———.
1957a. Effectiveness of various kinds of bait for catching channel catfish and carp in the Des Moines River. (Mimeo.) Iowa Conserv. Comm. Quart. Biol. Rept. Vol. 9, No. 2: 10-13.

———.
1957b. Des Moines River creel census, 1957. (Mimeo.) Iowa Conserv. Comm. Quart. Biol. Rept. Vol. 9, No. 3: 23-26.

Heacox, Cecil
1946. The Chautauqua Lake Muskellunge: research and management applied to a sport fishery. Trans. N. Am. Wildl. Conf. 11: 419-425.

Holloway, A. D.
1948. Twelve years of fishing records from Lake Mattamuskeet. Trans. N. Am. Wildl. Conf. 13: 474-480.

Houser, Alfred and William R. Heard
1958. A one-year creel census on Fort Gibson Reservoir. Proc. Okla. Acad. Sci. 38: 137-146.

Jackson, Samuel W., Jr.
1958. Summary of a three-year creel census on Lake Eucha and Spavinaw Lake, Oklahoma, with comparisons of other Oklahoma reservoirs. Proc. Okla. Acad. Sci. 38: 146-154.

Kathrein, J. W.
1953. An intensive creel census on Clearwater Lake, Missouri, during its first four years of impoundment, 1949-1952. Trans. N. Am. Wildl. Conf. 18: 282-295.

King, Willis and Warren Currier
[ca. 1951]. Angling returns from Little River, Great Smoky Mountains National Park, 1950. (Mimeo.) Tenn. Game and Fish Comm.

Klein, W. D.
1954. Who's a fish hog? Colo. Conserv. Vol. 3, No. 2: 14-15.

Lagler, Karl F. and Gerandus C. DeRoth
1953. Populations and yield to anglers in a fishery for largemouth bass, Micropterus salmoides (Lacepede). Papers Mich. Acad. Sci., Arts and Letters 38: 235-253.

Lewis, Wm. M.
1955. The fish population of the main stream of the Big Muddy River. Trans. Ill. Acad. Sci. 47: 20-24.

Lord, R. F.
1935. The 1935 trout harvest from Furnace Brook, Vermont's "test stream". Trans. Am. Fish. Soc. 65: 224-231.

———.
1937. Goofy business: is fishery conservation unbusinesslike? Prog. Fish-Cult. 33: 1-8.

———.
1941. Keeping books on a Vermont trout stream. Prog. Fish-Cult. 55: 19-22.

_____. 1946. The Vermont "test water" study, 1935 to 1945 inclusive. Vt. Fish and Game Serv., Fish Res. Bul. No. 2.

Mackenthun, Kenneth M. and Elmer F. Herman
1949. A preliminary creel census of perch fishermen on Lake Mendota, Wisconsin. Trans. Wisc. Acad. Sci., Arts and Letters 39: 141-149.

Manges, Daniel E.
1950. Fish tagging studies in T.V.A. storage reservoirs, 1947-1949. Jour. Tenn. Acad. Sci. Vol. 25, No. 2: 126-140.

Miller, Lawrence F. and Paul Bryan
1947. The harvesting of crappie and white bass in Wheeler Reservoir, Alabama. Jour. Tenn. Acad. Sci. Vol. 22, No. 1: 62-69.

Moore, Harvey L., Oliver B. Cope, and Richard E. Beckwith
1952. Yellowstone Lake trout creel censuses, 1950-1951. Dept. of the Int., U.S. Fish and Wildl. Serv., Spec. Sci. Rept. Fish. No. 81.

Moyle, John B. and Donald R. Franklin
1953. Creel census of 23 Minnesota lakes - 1952. (Mimeo.) Minn. Dept. Conserv., Fish. Res. Unit Rept. No. 135.

Mraz, Donald and C. W. Threinen
1956. Angler's harvest, growth rate and population estimate of the largemouth bass of Brown's Lake, Wisconsin. Trans. Am. Fish. Soc. 85: 241-256.

Muncy, R. Jess
1956. Walleye population in the Des Moines River study area. (Mimeo.) Quart. Rept. Iowa Coop. Wildl. and Fish. Res. Units Vol. 22, No. 1: 30-31.

_____. 1957. Distribution and movements of channel and flathead catfish in the Des Moines River, Boone County, Iowa. Unpublished Ph. D. Thesis. Ames, Iowa. Library, Iowa State University of Science and Technology.

Murphy, Leon W.
1955. Two-year creel census of the Little Salmon River, Idaho. Trans. Am. Fish. Soc. 84: 200-206.

Neuhold, John M. and Kuo H. Lu
1957. Creel census method. Utah State Dept. of Fish and Game, Publ. No. 8.

Nicholson, A. J. and M. Milton Borges
1955. Creel census and expenditure studies, Missouri River basin. Dept. of the Int., U.S. Fish and Wildl. Serv., Spec. Sci. Rept. Fish. No. 141.

O'Donnell, D. John
1945. A four-year creel census on the Brule River, Douglas County, Wisconsin. Trans. Wisc. Acad. Sci., Arts and Letters 37: 279-303.

Phenicie, C. K.
1955. Analysis of creel census data: I. Examination for fisherman success. (Mimeo.) Mont. State Dept. of Fish and Game, Job. Comp. Rept. F-4-R-4.

Randle, A. C.
1938. First progress report on the Squaw Creek test stream, Shasta National Forest. (Mimeo.) U.S. For. Serv.

Rehder, Dudley D.
1959. Some aspects of the life history of the carp, Cyprinus carpio, in the Des Moines River, Boone County, Iowa. Iowa State Jour. of Sci. Vol. 34, No. 1: 11-26.

Rupp, Robert S.
1955. Studies of the eastern brook trout population and fishery in Sunkhaze Stream, Maine. Jour. Wildl. Mgt. Vol. 19, No. 3: 336-345.

Schmulbach, James C.
[ca. 1959]. Growth of the walleye in the Des Moines River, Boone County, Iowa. Proc. Iowa Acad. Sci.

Schultz, Vincent
1958. A statistical evaluation of the reliability of hunter bag check data. (Mimeo.) Md. Agri. Expt. Stat. Misc. Publ. No. 304.

Shaw, Robt. H.
1959. Ames, Iowa. Unpublished data on soil and air temperatures in Iowa. (Private communication)

Shetter, David S.
1950. The relationship between the legal-sized trout population and the catch by anglers in portions of two Michigan trout streams. Papers Mich. Acad. Sci., Arts and Letters 34: 97-107.

Smith, Stanford H.
1950. Upper Sacramento River sport fishery. Dept. of the Int., U.S. Fish and Wildl. Serv., Spec. Sci. Rept. Fish. No. 34.

Snedecor, George W.
1956. Statistical methods. 5th ed. Ames, Iowa. Iowa State Coll. Press.

Solman, Victor E. F.
1951. The creel census in the national parks of Canada. Trans. N. Am. Wildl. Conf. 16: 225-232.

Starrett, William C.
1950a. Food relationships of the minnows of the Des Moines River, Iowa. Ecol. Vol. 31, No. 2: 216-233.

_____.
1950b. Distribution of the fishes of Boone County, Iowa, with special reference to minnows and darters. Am. Midland Nat. Vol. 43, No. 1: 112-127.

_____.
1951. Some factors affecting the abundance of minnows in the Des Moines River, Iowa. Ecol. Vol. 32, No. 1: 13-24.

_____ and Perl L. McNeil, Jr.
1952. Sport fishing at Lake Chautauqua, near Havana, Illinois, in 1950 and 1951. Ill. Nat. Hist. Surv. Biol. Notes No. 30.

Stroud, Richard H.
1949. Growth of Norris Reservoir walleye during the first twelve years of impoundment. Jour. Wildl. Mgt. Vol. 13, No. 2: 157-177.

Tarzwell, Clarence M.
1942. A second season of creel census on four Tennessee Valley Authority reservoirs. Trans. N. Am. Wildl. Conf. 6: 202-221.

_____ and Lawrence F. Miller
1943. The measurement of fishing intensity on the lower T.V.A. reservoirs. Trans. Am. Fish. Soc. 72: 246-256.

Thompson, Wm. H. and Don Hutson
1951. A ten-year creel census on Lake Pawhuska, Oklahoma. Trans. Am. Fish. Soc. 80: 11-27.

Thorpe, Lyle M.
1938. Pond fish management progress in Connecticut. Trans. N. Am. Wildl. Conf. 3: 469-477.

Trembley, Gordon L.
1954. Fishing results on Upper Woods Pond. Penn. Angler Vol. 23, No. 3: 2-5, 23.

U.S. 71st Congress, 3rd Session
1931. Des Moines River Iowa. Letter from Secr. of War, transmitting report from the Chief of Engineers on the Des Moines River, Iowa, covering navigation, flood control, power development, and irrigation. House Doc. 682, U.S. Govt. Printing Office.

U.S. Fish and Wildl. Serv.
1954. Creel census and expenditure study, Madison River, Montana, 1950-1952. Dept. of the Int., Spec. Sci. Rept. Fish. No. 126.

Van Meter, Harry
1954. Fishing improves in 1953. West Virginia Conserv. Vol. 17, No. 11: 21-26.

Vestal, Elden H.
1954. Creel returns from Rush Creek test stream, Mono County, California, 1947-1951. Calif. Fish and Game Vol. 40, No. 2: 89-104.

Wandell, Willet N.
1946. An intensive method of determining hunter numbers and activities. Trans. N. Am. Wildl. Conf. 11: 373-382.

Watt, K. E. F.
1956. Choice and solution of mathematical models for predicting and maximizing the yield of a fishery. Jour. Fish. Res. Bd. Canada Vol. 13, No. 5: 613-645.

Wood, Roy, Richard H. Macomber, and Robert K. Franz
1956. Trends in fishing pressure and catch, Alltoona Reservoir, Georgia, 1950-1953. Jour. Tenn. Acad. Sci. Vol. 31, No. 3: 215-223.

Younger, Roy R. and Paul E. Hamer
1954. New Jersey's salt water sport fishery inventory, 1953. Trans. N. Am. Wildl. Conf. 19: 423-429.

ACKNOWLEDGEMENT

This research was part of Project 1373 of the Iowa Cooperative Fisheries Research Unit which is sponsored by the Iowa State Conservation Commission and Iowa State University of Science and Technology with the cooperation of the U. S. Fish and Wildlife Service, Department of the Interior. To these agencies appreciation is expressed for the use of equipment, facilities, and financial assistance.

The author expresses special appreciation to Dr. Kenneth D. Carlander, Professor, Department of Zoology and Entomology, for his guidance during the research activities and assistance in the preparation of this manuscript. Gratitude is expressed also to Dr. Jean Laffoon and Dr. Calvin Fremling who made suggestions toward improvement of the manuscript. The author is indebted to Dr. Arnold Haugen for taking the pictures which appear on the frontispiece. Assistance rendered by many fellow graduate students in the collection of field data is appreciated and special thanks are due Dudley D. Rehder.

Unrestricted use of the facilities at the Des Moines Y.M.C.A. camp at Boone was greatly appreciated. The cooperation of the Des Moines River anglers, without whom the study could not have been accomplished, is gratefully acknowledged.

The author's wife, Pat, gave valuable assistance in

typing the first draft of the manuscript and in rechecking tabular summaries and original data sheets for clerical and arithmetical errors.

A P P E N D I X

Table 38. Schedule of angler counts for the 1957 summer season on a 6.5-mile section of the Des Moines River, July 7 to August 24, 1957.

Two-hour period	Day of the week						
	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
6-8 a.m.	Aug. 18	Aug. 5	July 9	July 17	Aug. 15	Aug. 2	July 27
8-10 a.m.	July 21	July 8	July 30	Aug. 7	July 18	Aug. 23	Aug. 17
10-12 a.m.	Aug. 4	July 22	Aug. 13	Aug. 21	Aug. 1	July 19	July 13
12-2 p.m.	July 14	Aug. 19	July 23	July 31	July 11	Aug. 16	Aug. 10
2-4 p.m.	July 28	July 15	Aug. 6	Aug. 14	July 25	July 12	Aug. 24
4-6 p.m.	Aug. 11	July 29	Aug. 20	July 10	Aug. 8	July 26	July 20
6-8 p.m.	July 7	Aug. 12	July 16	July 24	Aug. 22	Aug. 9	Aug. 3

Table 39. Schedule of angler counts for the 1957 summer season on a 6.5-mile section of the Des Moines River, August 25 to November 12, 1957.

Two-hour period	Day of the week						
	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
7-9 a.m.	Oct. 13	Sept. 16	Oct. 8	-	-	Sept. 13	Sept. 7
9-11 a.m.	Sept. 1	-	-	Oct. 30	Oct. 17	Sept. 6	Sept. 21
11 a.m. - 1 p.m.	-	-	-	-	-	-	-
1-3 p.m.	Oct. 27	Sept. 23	-	Aug. 28	Aug. 29	-	Oct. 5
3-5 p.m.	Sept. 15	Sept. 9	Nov. 12	-	Sept. 5	-	Oct. 19
5-7 p.m.	Sept. 29	-	Oct. 1	Oct. 23	-	Nov. 8	Nov. 2

Table 40. Schedule of angler counts for the 1958 spring season on a 6.5-mile section of the Des Moines River, March 22 to June 15, 1958.

Two-hour period	Day of the week						
	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
6-8 a.m.	June 8	-	May 13	May 28	-	Apr. 11	May 3
8-10 a.m.	June 15	Apr. 14	June 3	-	May 1	-	Apr. 5
10-12 a.m.	Apr. 13	-	May 27	Apr. 9	Apr. 24	-	Mar. 22
12-2 p.m.	Mar. 30	May 5	-	Apr. 2	-	June 13	May 17
2-4 p.m.	May 25	May 19	-	-	May 15	Mar. 28	Apr. 19
4-6 p.m.	Apr. 27	Mar. 24	-	Apr. 30	May 22	-	June 14
6-8 p.m.	May 11	June 2	Apr. 22	-	-	Apr. 18	May 31

Table 41. Schedule of angler counts for the 1958 summer season on a 6.5-mile section of the Des Moines River, June 16 to September 7, 1958.

Two-hour period	Day of the week						
	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
6-8 a.m.	June 22	July 14	Aug. 5	Aug. 20	Sept. 4	-	Sept. 6
8-10 a.m.	Aug. 17	-	July 22	-	July 3	July 11	June 28
10-12 a.m.	Sept. 7	-	-	June 18	Aug. 21	June 20	-
12-2 p.m.	July 20	-	Aug. 26	July 16	-	Aug. 1	July 12
2-4 p.m.	Aug. 3	Aug. 11	-	Aug. 27	Aug. 14	July 25	Aug. 23
4-6 p.m.	July 6	June 23	June 24	Sept. 3	Aug. 7	-	July 26
6-8 p.m.	Aug. 31	July 7	July 29	-	-	July 4	Aug. 9

Table 42. Schedule of angler counts for the 1958 fall season on a 6.5-mile section of the Des Moines River, September 8 to November 16, 1958.

Two-hour period	Day of the week						
	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
7-9 a.m.	Nov. 16	Oct. 20	-	-	Nov. 6	Sept. 19	Sept. 27
9-11 a.m.	Oct. 19	Sept. 8	-	Oct. 1	-	Oct. 24	Oct. 11
11 a.m. - 1 p.m.	Sept. 21	Nov. 10	Sept. 30	-	-	Oct. 10	Oct. 25
1-3 p.m.	Nov. 2	-	Oct. 14	Oct. 29	Sept. 25	-	-
3-5 p.m.	Oct. 5	-	Oct. 28	Sept. 10	Oct. 16	-	Sept. 13
5-7 p.m.	-	Nov. 3	-	Sept. 24	Oct. 9	-	Nov. 8

Table 43. Size distribution of channel catfish recorded in interviews with anglers during five seasons on a 6.5-mile section of the Des Moines River.

Season	Numbers in each total length (inches) class								
	6-8	8-10	10-12	12-14	14-16	16-18	18-20	Above 20	Totals
Summer-1957	60	208	123	126	54	19	6	3	599
Fall-1957	34	13	29	5	1	1	1	-	84
Spring-1958	3	40	44	26	6	3	1	-	123
Summer-1958	6	23	113	42	12	2	2	1	201
Fall-1958	10	5	7	6	1	-	-	-	29

Table 44. Size distribution of carp recorded in interviews with anglers during five seasons on a 6.5-mile section of the Des Moines River.

Season	Number in each total length (inches) class								
	6-8	8-10	10-12	12-14	14-16	16-18	18-20	Above 20	Totals
Summer-1957	2	118	344	52	8	6	5	4	539
Fall-1957	-	8	50	16	10	1	3	2	90
Spring-1958	-	36	70	20	6	4	5	12	153
Summer-1958	2	16	201	122	19	13	9	8	390
Fall-1958	-	3	30	32	-	-	1	1	67

Table 45. Size distribution of walleyes recorded in interviews with anglers during five seasons on a 6.5-mile section of the Des Moines River.

Season	Numbers in each total length (inches) class							Totals
	8-10	10-12	12-14	14-16	16-18	18-20	Above 20	
Summer-1957	7	14	19	3	-	1	4	48
Fall-1957	-	8	21	3	2	4	1	39
Spring-1958	-	2	8	1	1	1	-	13
Summer-1958	-	5	13	7	-	1	-	26
Fall-1958	-	-	5	5	-	2	1	13

Table 46. Size distribution of flathead catfish recorded in interviews with anglers during five seasons on a 6.5-mile section of the Des Moines River.

Season	Numbers in each total length (inches) class							Totals
	8-10	10-12	12-14	14-16	16-18	18-20	Above 20	
Summer-1957	1	2	-	2	2	2	3	12
Fall-1957	-	-	1	1	1	1	1	5
Spring-1958	-	-	2	2	-	1	3	8
Summer-1958	-	-	1	1	1	2	1	6
Fall-1958	-	1	-	1	-	1	-	3

Table 47. Size distribution of suckers (mostly from the genus Moxostoma) recorded in interviews with anglers during five seasons on a 6.5-mile section of the Des Moines River.

Season	Numbers in each total length (inches) class								
	6-8	8-10	10-12	12-14	14-16	16-18	18-20	Above 20	Totals
Summer-1957	-	1	1	3	4	2	1	-	12
Fall-1957	-	-	2	-	2	1	2	1	8
Spring-1958	-	2	16	34	13	3	3	-	71
Summer-1958	1	-	6	16	2	-	2	-	27
Fall-1958	-	2	4	2	1	-	-	-	9

Table 48. Size distribution of bullheads recorded in interviews with anglers during five seasons on a 6.5-mile section of the Des Moines River.

Season	Numbers in each total length (inches) class					Totals
	Below 6	6-8	8-10	10-12	12-14	
Summer-1957	13	32	1	-	-	46
Fall-1957	-	2	-	-	1	3
Spring-1958	-	2	1	-	-	3
Summer-1958	-	21	-	3	-	24
Fall-1958	-	2	-	-	-	2

Table 49. Size distribution of smallmouth bass recorded in interviews with anglers during five seasons on a 6.5-mile section of the Des Moines River.

Season	Numbers in each total length (inches) class					Totals
	6-8	8-10	10-12	12-14	14-16	
Summer-1957	-	2	8	5	6	21
Fall-1957	-	-	2	5	-	7
Spring-1958	-	-	2	5	1	8
Summer-1958	1	2	3	1	2	9
Fall-1958	-	-	-	1	-	1